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SOUTHEAST ASIA
REPORT
PAVE MACE/COMBAT RENDEZVOUS(U)

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PROJECT
Contemporary
Historical
Examination of
Current
Operations
REPORT

PAVE MACE/COMBAT RENDEZVOUS(U)

26 DECEMBER 1972

HQ PACAF

**Directorate of Operations Analysis
CHECO/CORONA HARVEST DIVISION**

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14. ABSTRACT <p>Project CHECO was established in 1962 to document and analyze air operations in Southeast Asia. Over the years the meaning of the acronym changed several times to reflect the escalation of operations: Current Historical Evaluation of Counterinsurgency Operations, Contemporary Historical Evaluation of Combat Operations and Contemporary Historical Examination of Current Operations. Project CHECO and other U. S. Air Force Historical study programs provided the Air Force with timely and lasting corporate insights into operational, conceptual and doctrinal lessons from the war in SEA.</p>					
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PROJECT CHECO REPORTS

The counterinsurgency and unconventional warfare environment of Southeast Asia has resulted in the employment of USAF airpower to meet a multitude of requirements. The varied applications of airpower have involved the full spectrum of USAF aerospace vehicles, support equipment, and manpower. As a result, there has been an accumulation of operational data and experiences that, as a priority, must be collected, documented, and analyzed as to current and future impact upon USAF policies, concepts, and doctrine.

Fortunately, the value of collecting and documenting our SEA experiences was recognized at an early date. In 1962, Hq USAF directed CINCPACAF to establish an activity that would be primarily responsive to Air Staff requirements and direction, and would provide timely and analytical studies of USAF combat operations in SEA.

Project CHECO, an acronym for Contemporary Historical Examination of Current Operations, was established to meet this Air Staff requirement. Managed by Hq PACAF, with elements at Hq 7AF and 7/13AF, Project CHECO provides a scholarly, "on-going" historical examination, documentation, and reporting on USAF policies, concepts, and doctrine in PACOM. This CHECO report is part of the overall documentation and examination which is being accomplished. It is an authentic source for an assessment of the effectiveness of USAF airpower in PACOM when used in proper context. The reader must view the study in relation to the events and circumstances at the time of its preparation--recognizing that it was prepared on a contemporary basis which restricted perspective and that the author's research was limited to records available within his local headquarters area.

A handwritten signature in cursive script, reading "Robert E. Hiller".

ROBERT E. HILLER
Director of Operations Analysis
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ABOUT THE AUTHOR

A 1960 graduate of the U.S. Air Force Academy, Major Richard R. Sexton served three tours in SEA--first in 1962 with Operation Farmgate, again in 1965-1966 as navigator on the AC-47 "Puff the Magic Dragon," and finally in 1971-1972 as Chief, CHECO, Det 1, Hq 7/13AF, Udorn RTAFB, Thailand. It was during this last tour that the present report was written. Major Sexton has over 5,000 total flying hours and over 300 combat missions in SEA. He holds the Air Force Commendation Medal, Air Medal with eight OLC's, and the Distinguished Flying Cross with one OLC. Major Sexton also holds a Master's Degree in History from the University of California, Davis, and has served at the Air Force Academy where he taught courses in Military History, Unconventional Warfare, and Employment of Airpower. Major Sexton has contributed to a number of CHECO studies. In addition to the present report, he co-authored OV-1/AC-119 and Hunter-Killer Team, and assisted research and writing efforts on the Bolovens Campaign and USAF Operations in Northern Laos, Apr 71-Nov 71.

Major Sexton is currently assigned to the 513th Tactical Wing (USAFE), Mildenhall, England.

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PREFACE

This study documents the conception, birth, death, and resurrection of gunship beacon offset firing techniques. Two entirely different systems--Pave Mace and Combat Rendezvous--are discussed. These systems enabled USAF fixed wing gunships to deliver safe, sustained, and effective aerial fire on enemy ground forces in close proximity to friendly forces when both are invisible from the air.

The primary purpose of this report is to show from well documented experience that these systems represent an in-being, revolutionary, all-weather, close air support capability never before achieved. The report also examines the sometimes unconventional, often torturous, and almost always frustrating process by which the USAF developed, tested, introduced, and finally used these systems in combat. In so doing it suggests some obvious lessons which may facilitate more systematic management of future weapons systems. The report also shows how interservice rivalry, roles and missions considerations, and force structure issues impeded and almost prevented the introduction of systems whose rapid deployment would have been in the best interest of both services. Hopefully, this experience may suggest how such opposition can be overcome in the future by showing how it was overcome in this instance. The report seeks to provide sufficient technical information about each system to enable the reader to understand how each system operates and to compare their relative merits and shortcomings.

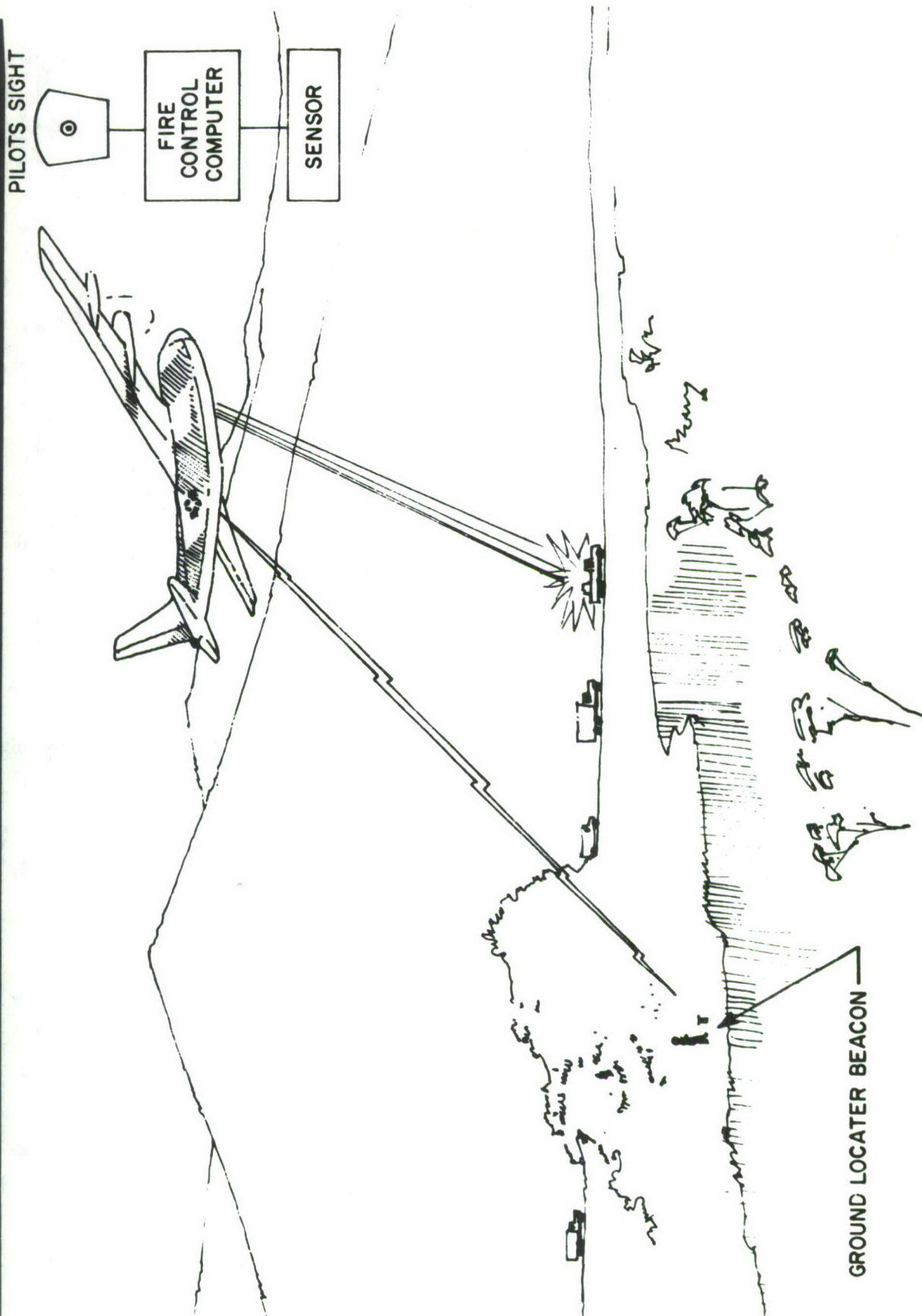
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In so doing it reveals a number of problems with both systems which have not yet been overcome and discusses possible solutions that have been advanced. Finally, this study shows how each system has saved the lives of friendly ground forces who would otherwise have died had it not been for these systems.

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CHAPTER I

INTRODUCTION

THE MAGIC FIRE ARROW

On a black and moonless night in 1965, an isolated South Vietnamese outpost came under attack by the Viet Cong. A single United States Air Force (USAF) FC-47* gunship (the only one in existence at that time) was dispatched to support the friendly forces. When the gunship was unable to locate the enemy position, the defenders of the fort lit their "fire arrow"--a large wooden arrow mounted on a swivel with flare pots along its head and shaft. By simply pointing the arrow in the direction of the enemy, and varying the number of flare pots, the defenders could indicate the position and the range to the target--each flare pot indicating 100 meters. Using this primitive device the gunship was able to direct its fire on the unseen enemy below.

Since the gunship was flying "black-out," it could not be seen from the ground. All that could be heard was the drone of its engines--and then a terrible roar as a tongue of fire seemed to burst from the heavens and lick along the ground. Then only the drone of the engines again. As the defenders shifted their arrow to the next target, there was another roar and the tongue of flame again seared its way through the enemy ranks. Still a third burst, and the Viet Cong fled in terror.

*Designation was later changed to AC-47. See Project CHECO Report; First Test and Combat Use of the FC-47, 22 July 1965.

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Never having seen an FC-47 before, the defenders inside the fort were filled with the same fear and awe as the enemy. What was this dread monster that breathed fire and destruction upon its foes? They began to gesture wildly toward the sky and scream "Rahng, Rahng" (Dragon, Dragon). Thus was born "Puff, the Magic Dragon," the first of a family of USAF fixed wing gunships.

Whether or not the above story is true or only a part of the legend of the FC-47 is unimportant. What is significant is that in the primitive fire arrow lay the basis for all future gunship offset firing techniques. In the years that followed, gunships increased dramatically in sophistication with the introduction of new aircraft, armament, and sensors.* The optical sight on the AC-47 was also replaced with an automated fire control system (FCS). The heart of this system was a fire control computer (FCC) which could accept inputs from any of the sensors and integrate them with aircraft altitude, airspeed, angle of bank, inflight wind, and bullet ballistics to establish the correct aiming point for the pilot. In the event that the target was not visible to the gunship but some other reference point was visible, range, and bearing (if known) from this reference point to the target could also be set into the FCC which would then compute an offset aiming point.

*For a complete history of USAF fixed wing gunship development see Project CHECO Reports: The Role of USAF Gunships in SEAsia, 30 August 1969, and Fixed Wing Gunships in SEA (Jul 69-Jul 71), 30 November 1971.

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The first field tests of computer offset firing were conducted in early 1969 using the AN/AWG-13 FCC on the AC-130. These tests revealed that the system was unreliable beyond 300 meters due to problems in the heading gyro and flux gate compass.^{1/} Additional tests at Lockbourne AFB in the summer of 1969 led to the installation of an improved heading reference system and an entirely new FCC, the AN/AWK-9.^{2/} By early 1970 a new computer, capable of accepting offset distances up to 1,000 meters with four mil accuracy, had been installed in all AC-119K and AC-130A gunships. However, the gunship was still limited to a fixed bank angle of 30°. Later improvements, incorporated into the AC-130E, enabled the AWK-9 to accept offset ranges up to 10,000 meters and variable angles of bank between 5° and 30°. ^{3/} As the procedures for offset firing were developed and formalized, they were incorporated into TACM/PACAFM 55-249, "Aircrew Operational Procedures for AC-119 and AC-130." Still, the gunship had to "see" the target, or a suitable ground reference point, with one of its sensors. Thus the gunship possessed only limited all-weather capability.

Simultaneously with the development of these follow-on gunships, the Aeronautical Systems Division (ASD) of the Air Force Systems Command (AFSC) began a search for ways to increase their all-weather capability. Eventually two systems--Pave Mace and Combat Rendezvous--emerged as the most effective solutions to the problem. Each system employed a ground beacon to provide a fixed reference point for the gunship regardless of weather. Range and bearing to the target could then be passed to the

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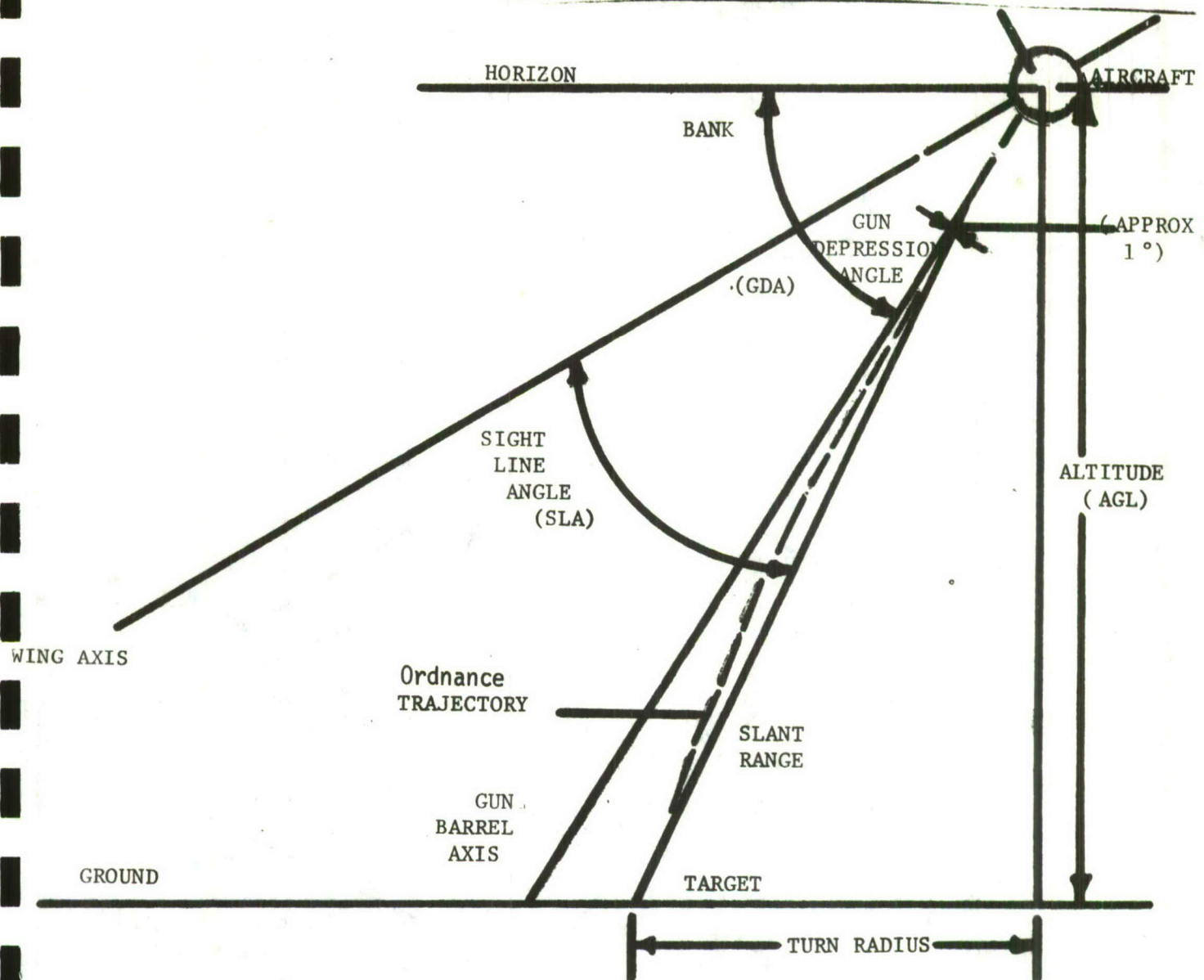
gunship and set into the fire control computer which would determine an offset aiming point for the pilot. By using this technique, the gunship could remain above the clouds and still direct its fire on the enemy position. Between them, Pave Mace/Combat Rendezvous systems represented a revolutionary breakthrough in all-weather close air support which added an entirely new dimension to USAF fixed wing gunship capability.

COMBAT RENDEZVOUS^{4/}

The Combat Rendezvous system consisted of an X-band radar beacon in conjunction with a side looking beacon tracking radar (BTR) in the AC-130 or AC-119K. This system was based on the same principle as the Identification, Friend or Foe (IFF) system and used many of the same components. The underlying principle had already been successfully employed in Combat Sky Spot (CSS). Both Tactical Air Command (TAC) and Military Airlift Command (MAC) had experimented with ground beacons for use in all-weather air drops, and the Rabat I and II beacons had been tried (unsuccessfully) with the F-4 and F-105. X-band crash locator beacons were built into a number of aircraft such as the OV-10 and several civilian models were available to hunters, light plane pilots, and boat owners. In addition, the Army and Navy had a number of ground radar beacons for their own use.

The beacon consisted of a transponder (such as that used in the IFF system), an antenna, a power supply, and a control unit. In general, there were two types of beacons: those with a single pulse reply only, and those with both a single pulse and several separate double pulse

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- *TAS = True AIRSPEED (Ideally 190 Knots).
- BANK = Bank Angle (Ideally 30°)
- GDA = Gun Depression Angle (in ° and ', approx. range 6° to 28°)
- SLA = Sight Line Angle (in ° and ', pilot's sight setting)
- *TS = Time of Fall (in seconds and tenths)
 - Slant Range (in feet)
 - Turn Radius (in feet)
- AGL = Altitude from Ground Level (in feet)
- *LAG = Gun Lag Angle (in ° and ')

*Indicates not depicted in figure

ELEMENTS OF THE FIRE CONTROL SYSTEM

FIGURE 2

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ATTACK ANALYSIS (OFFSET WITH WIND)

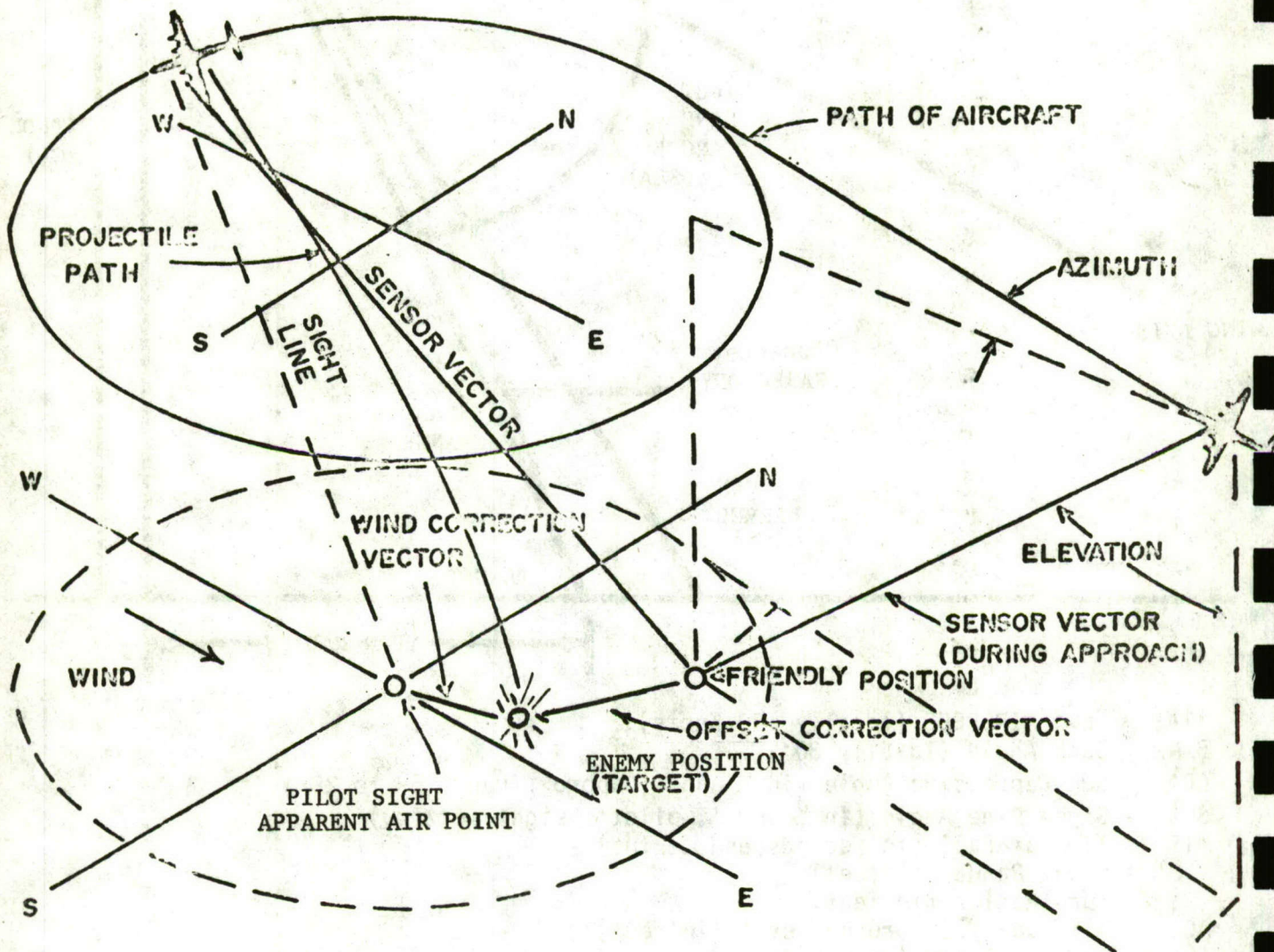


FIGURE 3

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replies. (See Figure 6 for a comparison of various beacons described in this chapter.)

The SST-201X Miniponder was a compact (two pounds) five watt transponder powered by a detachable battery, and was capable of eight hours of continuous interrogation use. The set could be operated in either the single pulse or any of nine coded double pulse replies. Nominal range was 10.5 nautical miles (NM), but this could be reduced to less than one mile in heavy jungle. Between 1969 and 1971, a total of 60 units were produced. Of these, 40 units were delivered to the Studies and Observation Group (MACSOG) in Vietnam, another 10 went to the 5th Special Forces Group in Vietnam and the remaining 10 sets were distributed to various Army and Navy units. A later model, introduced in 1972, had a power output of 12 watts; this increased the nominal range to 13 NM in the clear and improved performance under heavy jungle foliage.

The SST-181X transponder, which was used in the IFF system of the F-4 and other aircraft, also served as the basis for two ground radar beacons. The transponder had a power output of 400 watts (300 watts minimum) and featured both single pulse and nine coded double pulse replies. Minimum range was 1.2 NM in jungle canopy and maximum range was limited only by the acquisition capability of the BTR. The first beacon to utilize the SST-181X transponder was the AN/UPN-25, which was designed to be used with any 24-30 volt DC battery. This unit was purchased by the U.S. Army as a standard supply item.

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The AN/UPN-34, also an Army beacon, was basically identical to the AN/UPN-25. Unlike the latter, the AN/UPN-34 had a protective casing and used two PRC-64 dry cell replaceable but nonrechargeable batteries, which had a useful life of four hours of continuous operation. In early 1972, the USAF acquired 20 of these beacons for use in SEA. At 35 lbs, the UPN-34 was the heaviest of all the beacons.

The TAFSEA beacon, also known simply as the SST-119, employed the SST-119X 50 watt single pulse transponder. The unit, which weighed 20 pounds, was powered by five 6-volt batteries which could be recharged from any 120 volt 60 cycle source. However, because the batteries were not removable, the entire unit had to be returned from the field to be recharged. Battery life was 16 hours of continuous use and maximum range was 7.9 NM. In heavy foliage, the range was reduced to less than one mile. Eight of these beacons were acquired by the USAF in 1971 as a one-time purchase, and neither the beacon nor spare batteries were ever introduced into normal USAF supply channels.

At the same time, also as a one-time purchase, the USAF acquired 10 SST-125X air droppable beacons. Like the TAFSEA beacon, the SST-125X employed the SST-119X transponder operating only in the single pulse mode. However, the SST-125X was designed to be air dropped into an enemy position for direct fire. The SST-125X was powered by three PRC-64 batteries, capable of eight hours of continuous use. The entire unit was packed in a protective casing along with a parachute and a self destruct mechanism

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which could be set to activate in from two to eight hours. Power output and performance were identified with the TAFSEA beacon. In early 1972, the USAF ordered an additional 38 SST-125s, again as a one-time purchase.

In late 1971, the USAF adopted the AN/PPN-17 as its standard beacon and this unit was introduced into normal supply channels. Although smaller and lighter (17 pounds) than the UPN-34, it had the same power output (400 watts). However, the PPN-17 was not as ruggedly packed as the UPN-34 and thus was even more prone to damage under field conditions. Power was supplied by a single wet cell battery which was removable and could be recharged up to 20 times with a special charging unit. The unit could operate continuously for six hours on a single charge. The beacon was capable of operating in single pulse or any of seven coded double pulse modes. Range and other performance characteristics were similar to the UPN-34.

The HLR-2 was acquired in early 1972 by the 4802 Joint Liaison Detachment (CAS) for use by friendly Laotian ground forces. Details and specifications on this beacon were not available at the time this report was written.

All of the beacons were relatively delicate instruments and even with a protective casing were subject to failure under the rough handling normally encountered in field use. Since only the miniponders had a self test capability, and few were in Vietnam, it was generally difficult for the ground operator to tell if his beacon was operating properly. Two

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beacons deployed together could be used to check one another but this situation rarely occurred. The only other means of field checking the system was for a gunship to "interrogate" the ground beacon and tell the operator whether or not his set was working. If the beacon was not operating properly, the only action which the ground operator could take was to replace the battery. If the set still would not operate, it had to be returned to a supply depot for inspection and repair.

When the ground beacon was working properly, its signal could be detected by any radar operating in the beacon tracking mode, including the gunship's navigation radar. In the case of the more powerful beacons (UPN-25/34 and PPN-17), this signal could be received as far away as 60 miles. However, the firing geometry of the gunship required a continuous left turn and the navigation radar was not capable of angular tracking. Thus, a side looking BTR was required.

Two different radars, the AN/APQ-133 and the AN/APQ-150, were employed in Combat Rendezvous. Both were pulsed X-band BTRs capable of search, acquisition, and angular tracking of ground located beacons. Each system was composed of a receiver-transmitter unit (RTU) and a control-indicator unit (CIU). The RTU consisted of an antenna, transmitter, receiver, and signal processor mounted in a fiberglass radome on the left side of the aircraft. The control-indicator unit was located inside the gunship and consisted of a scope and operator controls. The weight of the entire system was approximately 400 lbs.

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The APQ-133, installed on the AC-119K and early models of the AC-130, had a power output of 300 watts, a range of 8.5 NM, and a tracking accuracy of four mils. The APQ-150, with an improved antenna and RTU, featured greater power (5000 watts), increased sensitivity, and finer tuning than the older BTR. These refinements gave the APQ-150 a range of 10.5 NM and an accuracy of two mils. The APQ-150 was mechanically more reliable than the APQ-133, and it could acquire and track beacons too weak for the older BTR to detect. Beginning in July 1971, the APQ-150 replaced the APQ-133 in the AC-130 gunships while the AC-119K continued to use the older model. Both sets were capable of tracking either single pulse or double pulse codes. In the case of a double pulse code, both the ground beacon and the control-indicator unit had to be set to the same code in order for the BTR to track the ground beacon. Tracking could be accomplished manually or automatically and both sets were able to distinguish between ground beacons operating on different codes within 50 meters of one another. However, beacons operating in the single pulse mode or on the same double pulse code required a 10 NM separation to avoid interference. The PPN-17 only required one NM separation due to an improved transponder design. However, in the case of the PPN-17, it was discovered that only the single pulse and one double pulse code were compatible with the APQ-133/150. The problem was that the pulse spacing on the PPN-17 was six microseconds while the signal processor in both BTRs was set for multiples of 12.3 microseconds. An in-theater fix eventually enabled the gunships to receive three of the double pulse codes as well as the single pulse reply.

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In order to be received by the gunship, the beacon had to be located in a relatively clear area. Sandbags could be placed around a beacon as long as the beacon itself was not covered. Further, the beacon had to be at least 10 meters from any radar-reflecting surface; if the beacon was placed inside a bunker or other building, its signal could not be detected by the gunship. Heavy jungle canopy significantly attenuated the signal. In addition, the beacons were subject to normal radar interference, especially from a nearby beacon operating on the same pulse code or from aircraft IFF systems set to the same code. Normally, aircraft IFF systems did not pose a serious problem. However, in areas of high aircraft density--such as were experienced at An Loc, Kontum, and Hue in early 1972--the beacons could become overloaded and would not provide a stable signal.

A false signal and side lobes could also be generated if the beacon was placed too close to radar-reflecting surfaces. In some instances, this would produce a "false" lock or prevent lock-on altogether. However, these false signals were easily recognized by the BTR operator who could manually lock on to the correct signal or request the beacon operator to move the beacon to a better location. If a positive lock could not be obtained, the beacon was considered to be inoperative.

When measuring the bearing from the beacon to the target, the beacon operator had to avoid holding his compass too close to the beacon since the beacon contained a powerful magnet. In addition, the range to the target had to be estimated as accurately as possible since the overall accuracy

of the system was largely dependent upon the range and bearing information passed by the ground operator to the gunship.

When everything was working properly and the gunship was locked on the beacon, the range and bearing to the target could be passed to the gunship and set into the FCC. From a nominal altitude of 5,000' above ground level (AGL) and a 30° bank, the four mil accuracy of the APQ-133 combined with the four mil accuracy of the AYK-9 to produce a circular error probable (CEP) of only 20 meters! Using the APQ-150 with its two mil accuracy, the CEP was reduced to 10 meters! When any one element of the system was not operating properly, it was recognized as a "no fire" situation. Thus, Combat Rendezvous was one of the safest and most accurate systems ever devised by the USAF.

PAVE MACE^{5/}

The Pave Mace system utilized a Tactical Electro-Magnetic Ignition Generator (TEMIG) beacon located on the ground in conjunction with the AN/ASD-5 Black Crow (BC) sensor and a TEMIG signal decoder in the AC-130. Although this system served the same purpose as Combat Rendezvous, it was based on an entirely different principle. The Black Crow sensor had been developed in 1967 to detect electromagnetic emissions from the spark plugs of an engine and was installed on the AC-130 to enhance its truck killing ability. The electromagnetic emissions from a truck's ignition system were picked up by the Black Crow sensor and presented as a distinct form of static in the operator's headset. At the same time, the signal was

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visually displayed on a control-indicator unit as a cluster of dots. The system was used for detection only since the visual display was too unstable to permit firing based solely on the Black Crow readings. Instead, the BC was used to vector the gunship into the vicinity of the trucks which were then picked up and attacked using one of the other sensors.

The TEMIG beacons were of two types--coded and uncoded. Both types produced the same characteristic signal as an automotive ignition system. However, the audio signal from either TEMIG was much stronger than the typical vehicular return and presented a very tight dot cluster which was sufficiently stable to permit the gunship to use it for either direct or offset firing. The coded beacons provided a coded identifier (ID) and, in case of TEMIG I, information as to range, bearing and type of target. Whenever the Black Crow was tracking one of the coded beacons within an 8-10 mil angle gate, the decoder--which could be installed on the AC-130 in less than an hour--would decipher the signal and present it as a sequence of two digit numbers. By consulting a Pave Mace checklist, the BC operator could convert this digital readout to range and bearing information to be set into the fire control system.

The Pave Mace decoder system used with TEMIG I was not a mandatory piece of hardware. As long as the Black Crow ASD-5 system was working, the TEMIG I could be acquired and tracked for close air support firing. The bearing and distance for ordnance impact had to be acquired by radio communications with a ground FAC, then the information was inserted into

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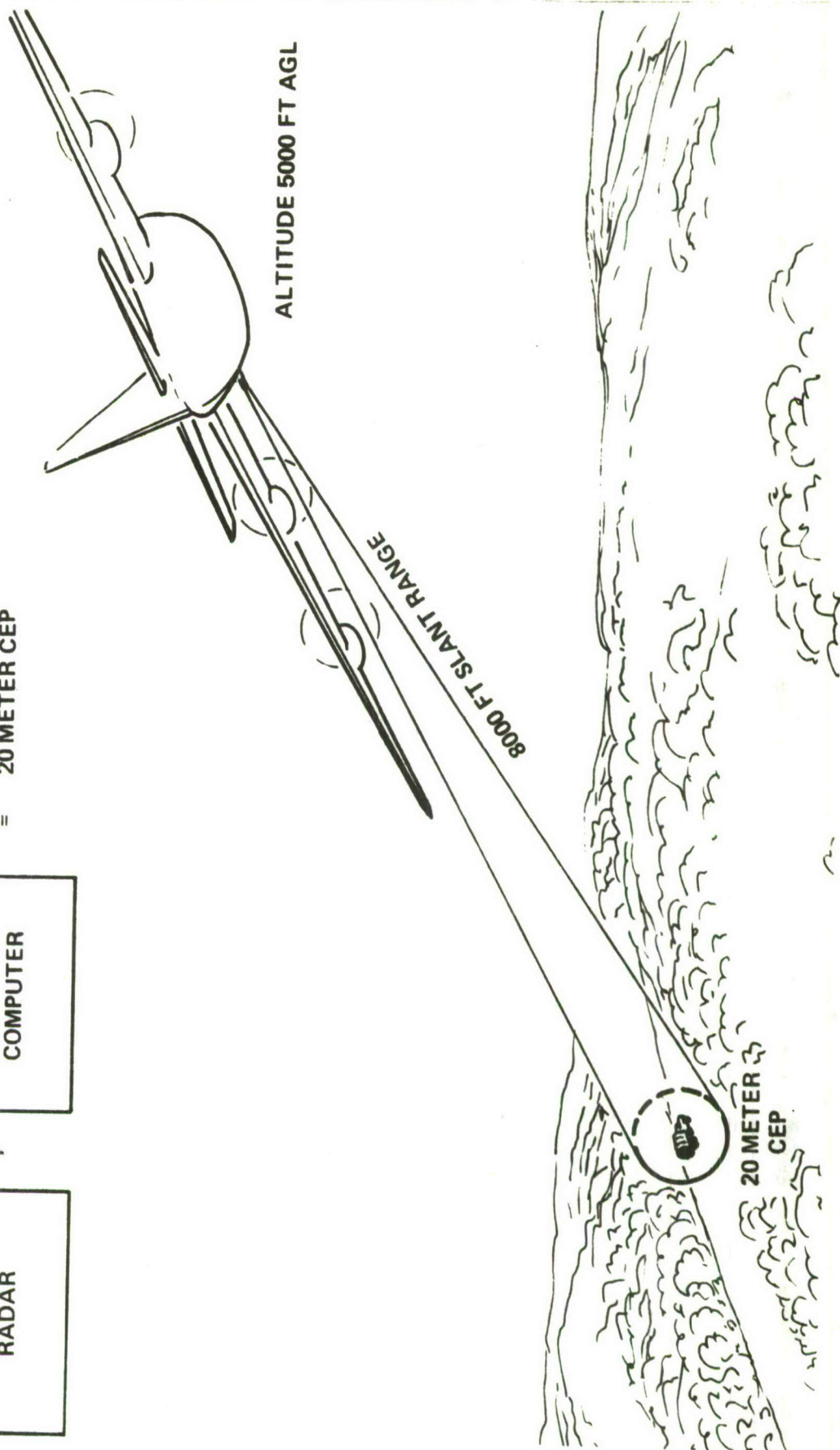


FIGURE 4

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the fire control system. The decoder compensated for a lack of radio communications or served to bridge a potential language barrier between ground and air elements.

Like the Combat Rendezvous system, Pave Mace was susceptible to interference from various types of electromagnetic "noise," especially from troposcatter communications systems. If this interference became so severe as to produce an unstable or diffuse dot cluster on the operator's scope, the system was not used for firing until the condition had been cleared up and a stable signal reestablished. TEMIG and X-band beacons would not interfere with one another, and, since the tracking angle gate on the BC was small (8-10 mils), there was little likelihood that two TEMIG beacons would interfere with one another if they were more than a few feet apart.

The TEMIG I was housed in an RT-10 survival radio and used the same batteries. Battery life was eight hours of continuous operation. Power output was 50-75 watts, giving the set a range of 8-10 NM under most conditions. The set, which weighed less than two pounds, was designed by the Naval Weapons Laboratory (NWL) in response to a requirement by CAS for a lightweight beacon for use by non-English-speaking ground forces. In addition to the ignition signal, the TEMIG I automatically transmitted a coded identifier. By operating a series of self explanatory dials, the beacon operator could designate any of five targets (personnel, supplies, radar, vehicles, and guns), and indicate range (in 100 meter increments out to

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1,000 meters) and bearing (in 36° increments). An improved version later reduced the bearing sectors to 18° increments and increased the range indicator to 2,000 meters. This information was received by the decoder and presented in a sequence of four 2-digit numbers, each of which remained on the screen for approximately 10 seconds. The cycle was then repeated until the beacon was turned off or changed to a new setting. The range setting was used to define the closest edge of the target area, e.g., a range setting of 400 meters meant that the target was between 400-500 meters and the fire control officer (FCO) would set 450 meters into the computer. The range indicator defined the center of a 36° (18° with the improved TEMIG I) sector. Thus the beacon designated an area, rather than a point target. Using the old TEMIG I, this area could be as large as 9,500 square meters at 250 meter range and 60,000 square meters at 950 meter range. The improved TEMIG I, while still intended for area coverage, reduced the target area by 50 percent.

Since all of the information was passed electronically, no voice contact was required, thus circumventing any language barrier that might exist between the gunship crew and the ground operator. In addition, the ground operator required a minimum amount of training since all settings were indicated by easily recognized symbols. Field checking the unit was virtually automatic since the range and target indicator lights were illuminated whenever the set was operating. If the set was turned on and the indicator lights were not illuminated, the only corrective action was to replace the battery. If the set still would not operate, it was simply returned to the NWL for repair. No in-theater repair was attempted.

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The TEMIG II was an uncoded "throw-away" beacon housed in an SDU/5E strobe light case and powered by the same battery. The unit, which provided an ignition signal only, was designed to be dropped into an enemy position for use in direct fire. Battery life was approximately six hours and the range was generally less than three miles in jungle but up to five miles in the clear. The beacon was turned on and off simply by inserting or removing the battery. Since the beacon did not transmit a coded ID, it was not necessary for the gunship to have a decoder on board; consequently, any gunship with the regular Black Crow equipment could detect and recognize the ignition signal. If the beacon was used by friendly ground forces, voice contact was necessary for the gunship to receive firing instructions.

Since the TEMIG II was intended for one time use, there was no built in test circuit and no dial lights or other visual indication that the set was operating. A small field checkout unit was available, but there is no record that they were ever deployed. In practice, the only way to field check the beacon was for a gunship to tell the ground operator whether or not it was working. If the gunship could not receive this signal, the only possible corrective action for the beacon operator was to replace the battery. If this did not correct the problem, the beacon was simply discarded.

Two model changes were subsequently introduced by the addition of new features to the TEMIG II. TEMIG III included a coded ID to facilitate its

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use by friendly ground forces; TEMIG IV also included the normal strobe light function which served both as a field check on beacon operation and as an additional aid to the gunship. Otherwise, these units were identical to TEMIG II.

TACTICS AND PROCEDURES^{6/}

Either AC-119Ks or AC-130s could be fragged or diverted to a Combat Rendezvous mission, but only the AC-130 was equipped for Pave Mace. It was the responsibility of the ground user to keep Seventh Air Force (7AF) or Seventh Air Force/Thirteenth Air Force (7/13AF) advised of the location, beacon ID, call sign, and radio frequency of all ground units equipped with TEMIG or X-band beacons so that this information could be made available to the gunship crews. If a beacon fell into enemy hands, the USAF was immediately advised and the beacon was earmarked for destruction. In a rapidly shifting ground situation, reporting changes in beacon status and location was sometimes delayed. Such delays caused problems for gunship crews and resulted in lost time as the gunships "hunted" for the beacon and sought to determine whether it was in friendly or enemy hands.

When a Pave Mace or Combat Rendezvous mission was preplanned, the ground user would provide 7AF or 7/13AF with the following information so it could be included in the frag order: the type beacon, ID (or the fact that it was uncoded), call sign and radio frequency of the user, location (e.g., Ben Het), grid coordinates, type of target (if known), and desired time on target (TOT). Normally, 24 hours advance notice was desired, but

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the mission could usually be fragged with as little as nine hours notice. Otherwise, the mission was handled as an "add on" or as a divert from some other mission. In the case of a divert, the same information that would normally be included in the frag order, plus any additional available information, was passed to the gunship via the Airborne Battlefield Command and Control Center (ABCCC).

When the wing received the frag, it would schedule the aircraft and crew for the mission and compute briefing and take off times allowing sufficient time for sensor alignment and wet boresighting* before the planned TOT. Prior to take off, the crew would accomplish a complete target study, including the following elements: specifics on type of target (with photos of the area if available), weather, location and status of friendly and enemy forces, target range and bearing from friendly forces, defensive threat, escape and evasion situation, ground controlling agency, and the best area for wet boresighting the guns. (Even when the aircraft was not scheduled for a Pave Mace/Combat Rendezvous mission, the briefing normally included information on all beacon locations within the gunship's area of operation in case of a divert.)

After take off the aircrew would align the sensors over the field using a beacon located on the airfield and check the operation of the TCC at varying offset ranges. During the alignment check, it was

*Wet boresighting consisted of firing at an easily identifiable target to insure that the guns and sensors were aligned with one another.

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necessary to place the navigation radar in standby since it operated on the same frequency as the BTR and would cause interference. Once the alignment check had been completed, the equipment was turned off or put in standby until needed. The gunship then wet boresighted the guns in a suitable area where visibility was sufficient to observe bullet impact. This was necessary to ascertain that the FCC offset mode was functioning properly and that the guns were actually within tolerance. (The requirement for wet boresighting could be waived in the case of a tactical emergency.

The gunship would arrive in the approximate location of the beacon as close as possible to the TOT, establish voice contact with the ground forces, and direct them to turn on their beacon. When the beacon was turned on, the beacon operator would ask the gunship if he could "see" the beacon. If the gunship could not pick up the beacon, the Electronic Warfare Officer (EWO) would instruct the ground operator to change batteries or recycle his beacon. Normally the sensor (Black Crow or BTR) would lock on and track the beacon automatically. However, if the set would not track or hold a good lock, the EWO could track the beacon manually and slave the infre-red (IR) or Low Light Level Television (LLLTV) sensors to his set, thus using a second sensor to hold a reference point and so assist in maintaining the proper orbit point. If the gunship was receiving the beacon, the EWO would verbally confirm beacon ID with the ground operator and receive authentication using the proper interrogation code for that time period.

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In order to preserve battery life, the ground forces would normally not activate the beacon until the gunship was in the area and voice contact had been established. However, in some instances, the beacon could be used to guide the gunship into the proper area. In the case of the X-band beacon, the gunship's navigation radar could be used to search the forward quadrants, locate the beacon as far away as possible, and guide the gunship into the best position to pick up the signal on the BTR (normally a point 1-1/4 miles to the right of the beacon).^{*} Since the range of the TEMIG beacon was line-of-sight under ideal conditions, the Black Crow could serve this same function. Once the gunship had acquired the beacon on the BTR or BC, the navigation radar was placed in standby to avoid any signal interference. As an added safety factor, the gunship used all available means (flares, smoke, strobe light, etc.) in addition to the beacon to positively identify the friendly position. LLTV or IR visual acquisition of the target designated for attack was preferred in troops-in-contact (TIC) situations, but due to weather, night conditions, and various other factors, offset firing was the more common approach. The beacons provided the surest means of identifying the offset point in either visual or instrument flying conditions.

Once voice and beacon contact were established, the ground operator briefed the gunship on the ground situation, friendly and enemy positions, and antiaircraft (AAA) threat (if known). The beacon operator would then

^{*}The APN-59 has been used by Spectre crews occasionally to home in on a beacon, but this is not a standard procedure.

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specify the type of target, its range and bearing from the beacon (in the case of the TEMIG I this was done electronically, but was confirmed verbally), as well as target elevation. This last bit of information was particularly important since the friendly forces were normally located on a hilltop with the enemy in the valley below (or vice versa), and differences in terrain had a pronounced effect on firing geometry. When the gunship acknowledged this information, the beacon operator could clear the gunship to commence firing.

The entire procedure sounds quite complex and time consuming. However, it was absolutely necessary in order to insure complete safety to the friendly ground forces, and in practice it rarely took longer than 10 minutes between beacon acquisition and clearance to fire. Entry into the firing pattern was normal* and all normal tactical restrictions (rules of engagement, TACM/PACAFM 55-249, 7AF Oplan 715 and 730, local tactics manuals, etc.) were observed. As soon as possible after being cleared to fire, the gunship would commence firing and continue to fire until one of the following transpired: the beacon was turned off; all available or fragged ammunition was expended; the mission was completed; the beacon operator directed cease fire; return to base was necessitated by low fuel, battle damage, or other operational requirements; ABCCC or other control agency terminated the mission; or if any crew member detected an unsafe condition. In the case of the TEMIG I, the gunship would also cease fire whenever the beacon code was changed to indicate a new target and would not resume firing

*See TACM/PACAFM 55-249.

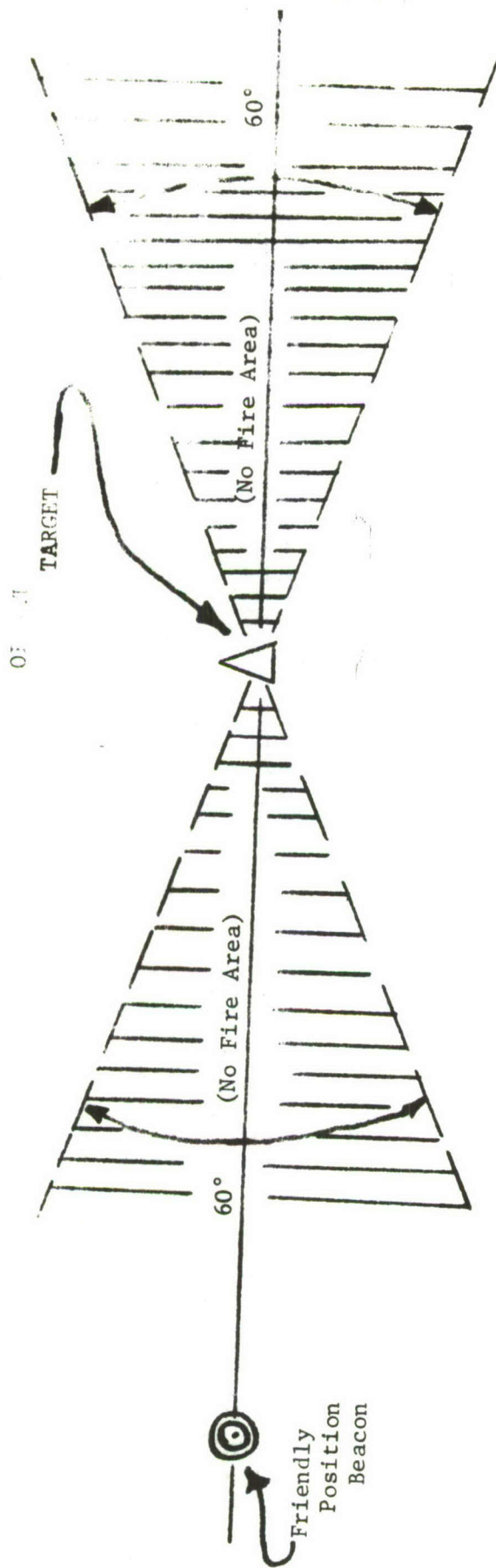
[REDACTED]

until the new signal had stabilized and been confirmed by voice contact. It was the responsibility of the pilot to select the proper ammunition for the target and to maintain the proper altitude and firing geometry. Normally, the sensor operators would try to hold one additional sensor on the friendly position and another on the target (weather permitting) to insure safety and observe bullet impact. The beacon operator would use normal procedures to adjust fire, usually starting with the farthest target and "walking" the bullets in closer to his own position. However, the gunship would not fire closer than 2000 meters to the friendly position under instrument conditions (IFR) or 100 meters under visual conditions (VFR) unless the ground commander was willing to take responsibility for any short rounds. (Other IFR systems, such as Loran and Combat Skyspot, were restricted to 3,000 meters from the nearest friendlies!) Nor would the gunship fire any time it was within 30° of a line between the friendly position and the target in order to avoid firing directly towards or over the head of the friendlies. When the mission was complete, the beacon operator would turn off the beacon and pass the mission results (BDA) to the gunship immediately if available or within 24 hours if possible in order to properly evaluate the mission. Due to the tactical situation, however, it might be days or weeks--if ever--before a gunship crew would know the full results of their mission.

In the foregoing discussion, the focus was on the utilization of manned beacons. When unmanned beacons were employed, procedures differed markedly. The controlling agency would normally clear the gunship to fire

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anywhere within 1,000 meters of the beacon. For that reason, it was necessary to ensure that the beacon was placed at least 1,200 meters (1,100 meters VFR) from the nearest friendly position. Since direct fire on an unmanned beacon was likely to destroy the beacon--thus automatically causing "cease fire" and terminating the mission--the gunship would normally not fire within 100 meters of the beacon but generally "hose down" the area out to 1,000 meters. The gunship would never fire directly on a coded beacon even when it was known to be in enemy hands unless it was specifically validated for destruction by the controlling agency. This would prevent the enemy from placing a captured beacon near a friendly position and tricking the gunship into firing on it. If there were any irregularities at all in the situation, the crew would simply hold their fire until they were positive that there was no danger to the friendly forces. These restrictions may seem severe but it should be pointed out that Pave Mace/Combat Rendezvous is the only Air Force weapon system that has never produced a "short round." This is due to the inherent accuracy of the system as well as the safety precautions and the skill of the aircrews.



The gunship will not fire within the sectors plus or minus 30 degrees either side of a line drawn between the friendly beacon position and the designated offset target

Gunship "No Fire" Area Determination

FIGURE 5

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CHAPTER II

DEVELOPMENT

COMBAT RENDEZVOUS

During the spring of 1968, the USAF offered to provide all-weather gunship support to the U.S. Army utilizing beacon offset firing.^{7/} The concept was to employ an ultra-high frequency (UHF) homing and ranging device on the AC-119G and an X-band BTR on the AC-119K and AC-130 gunships to target and offset from a ground beacon operated by friendly forces.^{8/} The only stipulation was that the Army provide the necessary ground beacons.^{9/} Since the Army was pushing for its own Advanced Aerial Fire Support System (AAFSS)--the Cheyenne helicopter--there was little interest in an Air Force project which might upstage this program. Consequently, the Army agreed to acquire the beacons only if the Air Force could prove the validity of the concept and the accuracy of the system.^{10/}

On 1 July 1968, the Army directed its Limited Warfare Laboratory (LWL), Aberdeen, Maryland, to evaluate both types of ground beacons for use with gunships.^{11/} Work on the UHF system never progressed beyond the initial test stage and that portion of the project was canceled in September 1969.^{12/} Meanwhile, work on the X-band beacons had been more successful and the Army proposed a two-phase program. Phase I was to be a feasibility test conducted in the U.S. If this test proved successful, Phase II would be a combat evaluation in Southeast Asia (SEA).^{13/} The USAF accepted this proposal, assigned the name "Combat Rendezvous" to

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the project, and directed TAC to conduct Phase I.^{14/} Details of the test program were worked out as a conference on 11 September 1968, and the demonstration scheduled for November at Eglin AFB, Florida, under the auspices of the USAF Special Operations Force (SOF).^{15/} Preliminary testing was completed on 15 October and the demonstration was held on 22 November in the presence of 96 observers from the Army and Air Force.^{16/} The demonstration consisted of live firings by both AC-119G and AC-130A aircraft using the AWG-13 FCC and APQ-133 BTR with an SST-201X "miniponder." Five Army observers--two from the LWL, two from the Special Warfare Center, Fort Bragg, North Carolina, and one from the Combat Development Command (CDC)--were on board the aircraft.

The AC-119 portion of the demonstration consisted of firing at four targets--two 50' x 50' panels and two areas with small stakes to mark the target center. All targets were fired upon using single passes except for the first panel target which was fired upon twice. The test report stated that:^{17/}

All targets were hit and indicated symmetrical pattern of bursts in all quadrants with max miss distance of 70 meters and a mean miss distance of 20 meters. Bullet holes were scattered uniformly throughout the 50' x 50' panels with 92 hits in the panel that was struck twice and 60 hits in the panel struck only once.

Six targets were used in the AC-130 demonstration. Two were 40 x 60 meter target areas containing 60 steel drums, two were 50' x 50' panels, and the other two were target areas marked by small stakes. To provide

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a comparison, three of the targets were struck using the X-band beacon and three were struck using other sensors. ^{18/}

On the first drum target, 11 drums received direct 20 mm hits and a total of 30 drums were punctured or showed evidence of shrapnel impact. Drums were hit in all quadrants from the center stake and the pattern would have to be considered a direct hit. Maximum impact distance from the stakes on this target was 20 meters. The first panel target was to have been struck using NOS/IR [Night Observation Sight/Infrared] offset from strobes and reflective panels. However, the fires from the drums 200 meters west obscured the IR model and the strike was conducted using FLIR offset from the burning drums. The impact pattern on this target was centered 18 meters west of the target center with a max miss distance of 300 meters. The third target was an area target struck by FLIR offset (80 meters) from the confluence of two small streams on the range. The impact pattern was centered on the target. The final three targets were struck in X-band radar offset mode simulating IFR conditions. The impact on all three were virtually identical with relatively tight groupings falling between 15 and 20 meters west of target centers. It is significant to note that all of the AC-130 targets were single pass targets and no corrections were attempted.

All of the observers were favorably impressed with the demonstration results and the test report concluded: ^{19/}

Believe that Phase I Combat Rendezvous demonstration was executed in a highly successful manner. If Phase II is implemented, USAF SOF will assist as directed.

The LWL report was also favorable but called for additional tests to determine the attenuation effects of jungle canopy on the beacon signal. ^{20/}

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In the meantime, field tests of the AWG-13 in Vietnam revealed that the computer was unreliable beyond 300 meters.^{21/} Additional live firings at Lockbourne AFB, Ohio, during the summer of 1969 confirmed these results and led to the installation of an improved gyro heading reference system which the Air Force considered suitable for close air support in SEA.^{22/} However, the Army had not yet conducted the attenuation testing of its ground equipment. This test, which used both the SST-201X and the UPN-34, was finally completed in Puerto Rico in early 1970 with full USAF support.^{23/} Results of this test showed that:^{24/}

Based on general observations, the five watt mini-ponder was useable only under clear line of sight conditions. The 400 watt UPN-34 performed satisfactorily in clear, medium and heavy canopy conditions. Extensive rainfall during the test period resulted in a substantial number of missions being flown in or above visible moisture thereby increasing the severity of the test environment.

Although these tests also showed a number of deficiencies in the APQ-133 radar, the LWL was generally satisfied with the results and certified the system for use in combat provided all airborne components were functioning properly. This certification also recommended a first fire safety criteria of only 120 meters from the nearest friendly forces--a clear indication of system accuracy!^{25/} However, the LWL added the stipulation that the system not to be used in IFR conditions unless backed up by another sensor.^{26/} Since at that time the gunship had no other sensors which were useable under IFR conditions, this provision in effect nullified the entire concept. Complete test results were discussed at a conference on 3 March and a final report was issued on 1 June 1970 without, however,

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clarifying the ambiguous position of LWL.^{27/} Subsequent events were to show that this inconsistency caused unnecessary delays in the combat application of beacon offset firing techniques.

Since the AC-119K and AC-130s had already been deployed to SEA, the Air Force was anxious to get the beacons into the field and proceeded with Phase II. Army commanders were also interested. In particular, the Americal (23d) Division, 5th Special Forces Group, and MACSOG had made informal requests for gunship close air support using Combat Rendezvous.^{28/} However, on 12 February 1970, Hq USAF noted that:^{29/}

U.S. Army LWL project personnel have been reluctant to formally provide shipment dates of SEAsia evaluation plans. One reason given is that they have not received necessary information from Army units in Viet Nam relative to recipients of transponders and employment procedures.

In spite of this reluctance on the part of the Army, the Air Force went ahead with its own plans. To implement Phase II, Seventh Air Force drafted a joint test order (JTO).^{30/} According to the proposed JTO:^{31/}

Phase II of Combat Rendezvous will be a combat evaluation of the X-band radar beacon/BTR system by operational units in Southeast Asia. . . .

A total of 13 missions was planned using the AC-119K and SST-201X "mini-ponder" with offset ranges varying between 50 and 500 meters. Each target was to consist of a series of panels and scoring would include the number of hits in the panels, average miss distance, maximum miss distance, and closest impact to the beacon. In order to conserve resources, the test

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was to utilize existing fragged missions which would proceed to the test area and complete their firing before continuing on their assigned missions. Only top priority missions such as TICs would divert the gunship from the test. Firing was to be conducted from 3,500' using the BTR only. Three bursts of three to five seconds each with a single 7.62mm minigun at low rate, and a one second burst with a single 20mm Vulcan, would be fired at each target. As a safety precaution, all targets would be marked with IR reflective panels and verified by the night observation sight (NOS) operator during a dry firing pass prior to live firing. As an additional safety factor, the initial missions would be flown in daytime VFR with a minimum of 500 peters between the target area and the ground observers.

Based upon the earlier test results, it was the Air Force view that the system was combat ready at this point. Thus, the purpose of Phase II testing was to:

- a. Establish the AC-119K tactical limitations of BTR firing.
- b. Evaluate BTR offset tactical procedures for Visual Meteorological Conditions (VMC) and Instrument Meteorological Conditions (IMC) combat environments.
- c. Establish BTR offset support air-to-ground communication procedures.
- d. Identify aircrew and ground force peculiar training requirements. ^{32/}

However, the JTO also contained some unfortunate wording--an escape clause--which the Army was quick to recognize. The JTO stated that the mission of the test was: ^{33/}

To demonstrate and evaluate the AC-119K BTR/X-band beacon offset weapon system for close air support in a combat environment.

To the Army this implied that Phase II was merely a feasibility test which should be properly conducted in the U.S. On 17 March, Military Assistance Command, Vietnam (MACV) informed 7AF that the proposed JTO was generally acceptable to the U.S. Army Vietnam (USARV) except that testing should not be conducted in the Republic of Vietnam (RVN) when it could be conducted in the continental U.S. (CONUS).^{34/} To reassure the Army, 7AF replied that:^{35/}

The purpose of Phase II Combat Evaluation is to develop operational procedures to be used by the ground forces and aircrews in employing the weapon system in the combat environment. Testing already accomplished in the CONUS will not be repeated during Combat Rendezvous Phase II.

Seventh Air Force went on to state:^{36/}

It was hoped that USARV would have developed sufficient confidence in the system to proceed with Phase II after reviewing the LWL report on the system. It is understood that USARV has requested further information from LWL on the system and its suitability for combat evaluation in SEA.

Unfortunately, the Army did not have the desired level of confidence and there is no record that the JTO was ever formally approved. Instead, the Army continued to find reason to delay testing. On 28 April, PACAF informed Hq USAF:^{37/}

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The Army seems reluctant to go ahead with Phase II of the test. USARV policy is that tests which can be conducted in the CONUS should not be conducted in RVN. Also, USARV wants the system to be certified prior to any operational evaluation of Combat Rendezvous. They appeared to be stalling because a great deal of data have been provided to LWL. Also LWL is balking on ground beacon shipment as a result MACV (USARV) freeze on Combat Rendezvous and the absence of offset fire certification. (sic.)

Hq USAF replied that: ^{38/}

The U.S. Army LWL proposed evaluation plan was forwarded to MACV approximately three weeks ago. This plan included LWL certification of the system as being suitable for close air support provided all applicable airborne components functioned properly. The plan also recommended a first fire safety criteria of a measured 120 meters between the nearest friendly forces and the target.

Since the Army was still unwilling to proceed with the test, Hq USAF ^{39/} informed PACAF:

The delays in initiating this evaluation show the lack of enthusiasm with which it is viewed by some Army elements. Hence recommend for AF to fully document instances where X-band transponders are used in close air support and also where lack of same has degraded gunship performance.

Meanwhile a number of X-band beacons had been shipped to Vietnam where they had found their way into the hands of MACSOG and the Special Forces. These organizations were less concerned with force structure issues than they were with the immediate tactical situation. In response to their urgent requests, 7AF notified 8th TFW that: ^{40/}

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AC-119/AC-130 aircraft are authorized to utilize FLIR/NOS/APQ-133 offset firing mode when in support of TICs in Steel Tiger East, south of 17 degrees north. These offset firing requests are associated with a bona fide emergency situation and every effort should be made to provide all possible support to friendly ground forces, to include firing through cloud layers using APQ-133/miniponder offset procedures. In the latter case friendly forces are assumed to be in extreme danger and the situation may be regarded as life or death.

Later, when the situation in the Central Highlands of Viet Nam began to deteriorate, 7AF informed the 14th SOW at Phan Rang: ^{41/}

Due to the present threat by enemy forces in Dak To/Dak Seang area and the potential threat to Special Forces Camps, you will, repeat will, be authorized to fire in the offset mode against enemy troops when the ground commander has an operational X-band beacon and requests offset firing. Air-to-ground communications are mandatory and normal DASC approval is required before firing.

The first recorded employment of Combat Rendezvous in RVN occurred on 17 April 1970. ^{42/} This was an informal test which had been arranged between the 14th SOW and the local Army commander through II DASC. The test consisted of an AC-119K making four firing passes using the various sensors. The first pass used the NOS offset 334° at 300 meters. A second pass used the Forward Looking Infrared (FLIR) sensor on the same target. The third pass was made on the same target using the APQ-133, and the final pass was made using the APQ-133 offset 339° at 600 meters. Weather conditions were VFR and firing was done from 3,500 feet. Visual observation revealed that all bullets impacted within 25 meters of the intended target. ^{43/} Although the results of this test were excellent, subsequent use of offset

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firing confirmed a deficiency noted in earlier test results: the AWG-13
FCC was unreliable at long ranges. On 2 May the 14th SOW informed ASD: 44/

This wing presently restricting offset firing to max of 300m. The data presented indicates that as the offset increases, the accuracy decreases but the safety factor with respect to the offset reference point is not necessarily degraded. We understand that accuracy degradation is due to Analogue Computer using small angle approximations and therefore is predictable. We further understand the error, magnitude and direction, is a function of position on the firing circle relative to the reference point.

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As a result of the 17 April demonstration, the Commanding General (CG), First Field Forces, Vietnam (I FFV), became interested in the project and, with the help of his Air Liaison Officer (ALO), arranged for a demonstration to be held at Nihn Hoa on 21 May. 45/ Two crews from the 18th SOS (AC-119K) were selected to take part in the demonstration which was to consist of firing two bursts at each of several point targets (55 gallon drums spaced to represent enemy positions). Unfortunately, the demonstration encountered a number of problems which prevented it from being a complete success. When the first gunship arrived over the test area, it was unable to achieve a positive lock due to a beacon malfunction. While waiting for a replacement beacon, the BTR antenna system malfunctioned, requiring the gunship to return to base (RTB). The second gunship was then called in but was only able to achieve an intermittent lock on the replacement beacon and the NOS had to be used to back up the BTR. However, this meant that the gunship had to drop 400' below its normal

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altitude in order to avoid clouds and maintain visual contact with the beacon position. This difference between actual and prescribed altitude introduced a certain amount of error in the AWG-13 computer. In addition, the beacon operator, who was a qualified forward air controller (FAC) but inexperienced in adjusting gunship fire, tended to overcorrect with the result that the second burst missed the target by as much as the first, but in the opposite direction. How much of this error was due to the FAC and how much was due to the FCC could not be determined but the overall effect was that none of the bursts scored a direct hit although all bullets were within 30-40 meters of the targets. There also appeared to be a significant difference between the bearing indicated by the FAC's hand-held compass and the aircraft compass values. Whether this was a result of the FAC holding his compass too close to the beacon or due to a compass error in the aircraft could not be determined, but it undoubtedly contributed to the accuracy problem. ^{46/}

Although the problems of weather, equipment error, and human judgment would be encountered in any combat situation, the 14th SOW felt that better results would have been obtained if a more realistic target had been selected. ^{47/}

One or two areas of simulated enemy concentrations, such as tree lines or stream beds, should be identified for attack instead of so many point targets. This would provide more time to adjust fire, more effective demonstration of gunship fire power over the target, and be more representative of a typical tactical situation.

One of the Air Force observers, Brigadier General Walter T. Galligan, agreed and went on to point out: ^{48/}

I believe the main point of the demonstration was missed by all present, i.e., no matter where the bullets impacted they never were a hazard to the friendlies located with the beacon. An enemy attacking the beacon position would have suffered heavy casualties whereas the friendlies were immune from the gunship's deliveries. This in itself warrants employment in combat situations as soon as we, Army and Air Force, develop and approve the necessary joint identification and communication procedures. Further field firings appear to me to be pointless.

Although the Air Force considered this test to be the beginning of Phase ^{49/}
II the Army obviously did not. In his report, General Galligan noted:

If the purpose of the subject demonstration was to generate enthusiasm among senior Army commanders for the use of the radar offset firing mode, I do not think that the objective was achieved. Despite Air Force disclaimers to the contrary it was clear that the Army observers considered the demonstration a test of system accuracy and, to some extent, an attempt to sell the system. My assessment of the Army's reaction is that it was an interesting demonstration of an experimental system which is not yet fully developed but which has sufficient potential to justify additional test firings.

I understand that the 7AF position is that Combat Rendezvous Phase I provides sufficient evidence concerning system accuracy and reliability to form a sound judgement concerning operational employment. I believe we should resist any attempt by the Army to institute a program to revalidate system performance.

[REDACTED]

While not all of the Army observers were impressed by this demonstration, the CG, I FFV, recognized the potential of the system for the defense of fire support bases and border outposts which were under heavy enemy pressure. On 27 May, he requested 7AF to provide an X-band beacon for use at Dak Pek to train Army personnel in the use of Combat Rendezvous.^{50/} The concept of operation was to use existing fragged missions on an "as requested" (through II DASC) and "as available" basis to strike area targets (such as those suggested in the 14 SOW message of 24 May) rather than point targets.^{51/} Since the number of beacons in-theater was extremely limited, it was not until August that 7AF was able to obtain a UPN-34 from MACSOG to support this request; subsequent records revealed only one test of the Combat Rendezvous system at Dak Pek.^{52/} However, between 15 June and 15 July, Combat Rendezvous was used successfully on three occasions at various Special Forces camps.^{53/} Following the 21 May test, the 14 SOW had developed a correction factor to be applied to the fire control computer, and subsequent firings were reported by the ground commanders as being very accurate. Although all firings were conducted in VFR conditions, one ground commander stated that he would be willing to permit firing within 50 meters of his position in IFR conditions.^{54/}

In spite of these successful firings, USARV continued to delay Phase II pending the arrival of a representative from the Department of the Army (DA). On 1 July the 14 SOW noted:^{55/}

We suggest that it is difficult to detect in the quoted message (CGUSARV 061000Z June 70) very much enthusiasm on the part of USARV for expediting combat employment of beacon tracking radar (BTR). We hasten to endorse General Galligan's views expressed in paragraphs 5 and 6 of message 14 SOW 240426Z May 1970, and agree that any further program to revalidate systems performance is unnecessary to justify operational employment. Every operational employment and demonstration conducted by the 14 SOW to date, with the sole exception of Nihn Hoa, has been an unqualified success. You are aware of recent use of beacons in Bung Lung/Ba Kiev area and we continue ready to help in any way possible.

Up to this point, all firings had been conducted by the 18 SOS (AC-119K0).
In response to an inquiry from the 16 SOW (AC-130) 7AF stated: ^{56/}

MACV and USARV do not want to start the combat evaluation until such time as the USAF has provided the Army with a certificate stating that the system is suitable for close air support. 7AF has requested Hq USAF to provide this certification. . . . The 16 SOS will not be involved in Combat Rendezvous Phase II but may be requested to provide close air support to the Army using offset firing at any time.

Subsequently, attempts were made to use Combat Rendezvous in support of ground forces on four occasions, but none proved successful, due to airborne or ground equipment malfunctions. These missions confirmed the results of the Puerto Rico test that the SST-201X "miniponder" was unsuitable for use in jungle canopy. The UPN-34, though heavier, was more successful than the SST-201X. However, none of the transponders had been acquired through normal supply channels and, consequently, routine preventive maintenance and performance testing were not accomplished. The ground units were subjected to rough handling by people not familiar with their

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operation. As a result, they tended to fail just when they were needed. This problem was compounded by the fact that neither the early model mini-ponder nor the UPN-34 had a built in test circuit and there was no way for the operator to determine if his beacon was functioning properly.^{57/} At the same time, the Air Force experienced problems in maintaining the APQ-133, especially since it was used so infrequently. If the equipment was not functioning, the gunship simply did not fire. Thus under no circumstances was there any danger to friendly ground forces. However, when everything was functioning properly, the system proved to be extremely accurate and although it was never used in actual IFR conditions there was nothing to indicate that accuracy under such conditions would have been impaired. Interestingly, the APQ-133 antenna housing, by increasing the drag on the AC-119K, reduced its TOT by an average of 20 minutes.^{58/}

Throughout the spring and summer of 1970, the Air Force sought to get an effective weapon system into the hands of the ground force. However, Army indifference--or opposition--made it virtually impossible to overcome the problems inherent in any new system. Because the program had not been centrally and systematically administered, the entire operation had proceeded on an ad-hoc basis and standard air/ground procedures were never formulated. Further, the Rules of Engagement (ROE) for South Viet Nam stated that all strike aircraft would have visual contact with the target when firing in support of troops.^{59/} This restriction alone was sufficient to cripple the entire program; yet there is no record of any attempt to have the rules changed until over a year later.^{60/} As a result of these

circumstances, the use rate of Combat Rendezvous was too low to permit either the aircrews or the ground forces to develop sufficient experience with, and confidence in, the system.

As a result of these obstacles, enthusiasm for the project gradually waned at 7AF and PACAF--though not at Hq USAF and ASD. Because of the low utilization rate of the Combat Rendezvous system, on 2 November 1970, the 14 SOW requested permission to remove the APQ-133 radar in order to improve their TOT.^{61/} In addition, the 400 pound weight saving could be translated into an equivalent amount of additional ammunition. Their proposal included provisions for storing and checking the units to permit their prompt reinstallation (requiring a total of six hours) should that prove necessary.^{62/}

As early as June, the Air Force had warned the Army that continued delays would jeopardize the entire program. According to this AF message:^{63/}

. . . We have . . . possessed for some time the capability to support SEAsia evaluation or operation with systems of demonstrated suitability. . . . However continued maintenance of this capability cannot be justified unless the Army makes an early decision to procure and field operational quantities of X-band ground transponders. . . . Request your early consideration of a decision on radar transponders and conduct of a SEAsia evaluation.

However, the Army halted further procurement of X-band beacons and spare batteries, virtually killing the program.^{64/} The ostensible reason behind the Army's decision was the result of a demonstration which was supposedly held at Dak Pek in Aug-Sep 1970 for the benefit of a DA representative.^{65/} (However, no record could be found of any DA representative being present

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at the one firing held at Dak Pek in August 1970, nor did records exist^{66/} revealing that a subsequent demonstration occurred at that location.^{66/}) Because of the variety of problems, the Air Force indefinitely suspended the project.^{67/} On 14 November, PACAF authorized the 14 SOW to remove and store the APQ-133 radar, and on 3 March 1971, because of funding considerations, lead time, and the planned transfer of the AC-119K to the VNAF, 7AF cancelled Combat ROC 52-70.^{68/} PACAF followed suit on 8 March, and the following day, due to the problems surrounding Combat Rendezvous testing, Hq USAF cancelled the test program.^{69/} However, Hq USAF made it clear the test program was cancelled because the system was operational.^{70/}

This Hq does not consider the Army decision as final action. As the initial follow on action, we are asking the Army to detail the unsatisfactory aspects of the concept. Subsequent actions will be determined to some extent by the Army reply. . . . Our position is that the gunship/transponder concept has been fully tested in CONUS, successfully employed in combat, and that further tests/demonstrations are unnecessary.

Despite this disclaimer, Combat Rendezvous was dead--at least for the time being. During the spring of 1971, ASD made several attempts to revive the program based on the introduction of the APQ-150 BTR and AYK-9 fire control system which were to be installed in the AC-130E gunships. However, it is unlikely that these efforts would have been successful had it not been for the advent of an entirely new IFR offset system--Pave Mace.

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PAVE MACE

One of the earliest organizations to become interested in beacon offset firing was CAS, which was looking for some means of all weather support for its Laotian ground forces. Due to its unique role in the Laotian war, CAS was primarily interested in a system for use in TIC situations. This consideration virtually precluded use of Loran and Combat Sky Spot. Hence they followed the development of Combat Rendezvous very closely. However, they quickly recognized that Combat Rendezvous would require extensive air/ground communications and identification procedures which in turn would require an English speaking ground observer and a trial and error firing phase.^{71/} They also recognized the mechanical problems which the X-band beacons were encountering. What CAS wanted was a simple, reliable, lightweight beacon which could be used by people with a limited command of English and virtually no mechanical background.

In response to this requirement, the NWL, in conjunction with the USAF, developed the TEMIG family of beacons, while Lockheed Missile and Space Company (LMSC) developed the associated BC decoder.^{72/} CAS considered the TEMIG I to be the first ground beacon to achieve a true air/ground link with friendly forces for TIC support. Because of its mechanical simplicity and pictorial presentation, it bridged the language barrier and required a minimum of knowledge on the part of the ground operator. This latter point was especially important due to the high attrition rate among the FAGs and the minimum amount of training given to replacements. The beacon could be quickly acquired by the gunship, and

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its positive authentication feature identified both friendly and enemy positions thus permitting the gunship to open fire almost immediately.^{73/} The TEMIG II, III, and IV did require voice contact when used by friendly forces but they were even lighter and simpler than the TEMIG I. They were originally intended as throwaway beacons which would be used primarily to mark an enemy's position.

To support the CAS program, Hq USAF established a test program under the code name Paye Mace. CONUS testing was limited to acquiring, lock-on, and tracking of the beacon. No live firings were conducted since the only differences between Paye Mace and Combat Rendezvous were the ground unit and the airborne sensor. Once the offset information was fed into the fire control computer, actual firing was identical in both systems. During these tests, the Black Crow was able to track the TEMIG beacon as well as the APQ-133 tracked the UPN-34, and the system was certified by virtue of its similarity as combat ready.^{74/}

On 22 March 1971, two officers from ASK arrived at Ubon Royal Thai Air Force Base (RTAFB) with eight TEMIG beacons (six TEMIG Is and two TEMIG IIs) and six decoder units for installation on the AC-130 Black Crow system.^{75/} The entire program was conducted outside the normal materiel channels and without the coordination of PACAF or 7AF. Because of this irregular procedure, the operations section became responsible for equipment that would normally be managed by the materiel section. No operating or maintenance manuals, technical data, special tools, or

estimates of manhours of support required were provided, and ASD, CAS, 16 SOS (8 TFW), and 7/13AF were left on their own to develop a program. ^{76/}

Within a matter of days, however, all of the decoders were installed, a tentative concept of employment had been developed, initial testing had been completed, and the beacons turned over to CAS for distribution to the field. The first actual Pave Mace combat mission was flown in the Barrel Roll area on the night of 4 April using a TEMIG I. A Laotian FAG, who had been thoroughly briefed and checked out in the use of the beacon, was inserted into a key position southeast of Ban Na (LS-15). The aircrew was thoroughly briefed on the details of the planned mission and had flown several practice missions to become familiar with the operation of the airborne equipment. Weather was VFR and voice contact was established with the FAG to insure safety and to validate the target area. The pilot was able to acquire and track the beacon with no problem, and all firing was conducted using the Pave Mace system and the AYK-9 FCC at offset ranges varying from 200 to 1,000 meters. ^{77/} Mission results were little short of spectacular: two secondary fires and two secondary explosions were observed, and one 82mm mortar position and a 12.7mm heavy machine gun position were destroyed. ^{78/} Following this mission, Major General Andrew Evans, Deputy Commander, 7/13AF, informed 7AF: ^{79/}

Last night we demonstrated the Pave Mace system in support of a key position southeast of LS-15. In my opinion the results were spectacular. A beacon was used by a Lao ground FAG to direct the AC-130 strikes against NVN surrounding his position. Initially the targets fired upon were 1,000 meters from friendly

positions. The accuracy was so great that the FAG called for strikes progressively closer to friendly positions during the almost 2 hour mission. Strikes near the end of the missions with both 40mm and 20mm were called for within 200 meters of the friendlies, and the closest hits were within 150 meters of friendlies, a spread of not more than 50 meters from the desired point of impact.

This message was accompanied by a request that additional AC-130s be made available on a regular basis to support Barrel Roll operations.^{80/} However, Seventh Air Force denied this request due to the higher priority given to the interdiction campaign in Steel Tiger.

The second Pave Mace mission, using an unmanned TEMIG II, was flown in Steel Tiger during the day of 12 April. Again the aircrew was thoroughly briefed and the beacon was dropped into an area of enemy concentration by a Raven FAC who remained on station to validate the target. The target area was located in a small valley surrounded by high terrain and covered with triple canopy jungle. Weather was 6/8 to 8/8 overcast and the gunship was in the clouds approximately three-fourths of the time. The beacon was initially acquired and tracked between three and four miles from target; however, it was very weak and after a short period became unusable. Thereafter, the gunship relied entirely upon its other sensors and the FAC. The following day a sweep of the area by a friendly ground team revealed 29 killed by air (KBA), one mortar position and two structures destroyed, three bunkers uncovered, and numerous blood trails leading from the area. However, these results were the result of the aircraft sensors and FAC rather than the Pave Mace system.^{81/}

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The third mission, on the night of 15 April, was again in Barrel Roll. (In this case, however, the mission was a divert from Steel Tiger.) Both the aircrew and the FAC were familiar with the system; thus, acquisition, tracking, and voice contact were normal. However, considerable confusion existed in the 7AF Command Post (Blue Chip) and the Airborne Command Post (Alleycat)--neither of which were familiar with the system--with the result that proper coordination was not achieved and the mission was a complete failure. ^{82/}

The final Pave Mace mission was by far the most ambitious of the series. On 16 April, a FAG equipped with a TEMIG I was infiltrated by an Air America helicopter onto the Bolovens Plateau along with a six-man tactical air control party. The group then made its way overland to Ban Nam Tieng (LS-165). It had been hoped that along the way they would be able to locate enemy positions in the area and direct airstrikes against them. The team was then to move to other areas on the eastern Bolovens, searching out lucrative targets and directing gunship strikes. By 18 April, the team was in position near LS-165. The first AC-130 Spectre arrived on station at 0330Z and after some difficulty locked on to the beacon; voice contact was established. However, since the ground team had been unable to locate any targets, the mission was used to familiarize the crew with TEMIG operations. ^{83/} Subsequently, no missions were fragged and the ground team was eventually withdrawn from the field.

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These tests were conducted under far from controlled circumstances and only one of the four missions was a complete success. Yet, they represented valid tests of the system under actual combat conditions and the problems encountered were typical of the "teething" process of any new system. They also provided the necessary information to resolve problems and develop a meaningful concept of operations.

The first and fourth missions showed that gunships could acquire and track the TEMIG I and that a FAG could control the gunships and direct their fire. The second mission suggested that the TEMIG II might be too weak to operate in heavy jungle or might be damaged by air drops, but could be useful in a clearing such as a prepared defensive position or in open terrain. The second and third missions also demonstrated the vital importance of familiarity with system operation and coordination among all of the agencies involved.^{84/}

All of the missions disclosed other problems which needed attention. On some units the azimuth knob slipped, antenna connections were faulty, battery life was less than desired, and there was no built-in circuit tester on the TEMIG II. Additionally, there were too many beacon failures, it took too long to resupply batteries to remote sites, and there were not enough units and spare batteries. Further, at long ranges the target area was too large for accurate firing. Finally, there were scheduling problems since only six aircraft were equipped with the TEMIG decoder.^{85/}

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When beacons were needed in the field, it was the responsibility of Operations or an ASD staff officer to get the beacons to the users and instruct them in its use. When the user was finished with the beacon or when it failed, these same officers picked up the beacon and returned it to Ubon or shipped it back to the NWL for repair. As 7AF^{86/} pointed out:

These are not Operations or ASD staff functions. They are Materiel responsibilities and ASD should have incorporated the beacons into standard materiel channels before they were introduced to tactical operations.

Given the Army's reluctance to become involved in any beacon offset firing program and the problems encountered during Combat Rendezvous, ASD felt that "standard materiel channels" would result in inordinate delays and that quicker results could be achieved by going directly to the field units.^{87/}

The Air Force, however, was not discouraged by the modest results achieved or by the problems encountered; rather, the potential of the system was recognized. On 17 April, 7/13AF reported:^{88/}

It still appears this system will provide a much needed all weather capability to be used in support of ground action when inclement weather precludes armed recce of the LOCs. Additionally, it could complement our interdiction program as indicated by the results of test number two.

At the request of Major General Joseph A. Wilson, 7AF DO, MACSOG was briefed on the results of the Paye Mace test. Due to the cancellation of Combat

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Rendezvous, MACSOG expressed great interest in its application to their operations. As a result of this briefing, MACSOG made arrangements to obtain two TEMIG Is and two TEMIG IIs for distribution to their field units. ^{89/}

After reviewing the results of the Pace Mace missions, 8TFW and 7/13AF proposed a meeting with 7AF to resolve planning, coordination, communications, and execution procedures. They also recommended that no demonstrations for outside agencies, including MACSOG, be scheduled until these issues had been resolved and a more reliable mission capability had been achieved. ^{90/} On 28 April 7AF replied: ^{91/}

This Hq does not concur in the proposal to convene a Pave Mace Conference at this time. It is anticipated that few if any AC-130 hours will be available for Pave Mace evaluation or operation during the next 30-45 days for it is desired maximum utilization be made of these resources in the interdiction campaign.

However, this message indicated continued 7AF interest in Pave Mace despite the immediate unavailability of test aircraft. The message added: ^{92/}

Request comments and proposals concerning Pave Mace utilization be forwarded to this Hq for review and consideration. No MACSOG commitment will be made until you are ready.

Although somewhat disappointed, 7/13AF replied: ^{93/}

[REDACTED]

7/13AF, 8TFW and 4802 JLD (CAS) will continue to press forward to develop OP's Plan for use of the TEMIG transponder when and if approval is received for use. 94/

Later, in response to continued MACSOG interest, 7AF informed 7/13AF: 94/

Concur with your proposal to develop an OPLAN for use of the TEMIG transponder. Request advisories concerning progress and recommended date for operator-user meeting when prepared to brief and demonstrate the system to ground force users. 94/

MACSOG has indicated a desire to employ the system and has taken action to procure ground transponders. This headquarters will assist in arrangements for MACSOG representatives to be present.

Indeed, 7/13AF, 16 SOS, CAS, and ASD were already well advanced in their plans. As early as 17 April, they had worked out a tentative agreement on a division of responsibilities. According to this document, CAS would (1) maintain a current listing of all active TEMIG beacons by number, location, call sign, and frequency. (this list would be continuously updated and forwarded to 7/13AF for retransmission to the 16 SOS); (2) furnish sufficient maps, photos, and authenticators for 16 SOS to develop mission briefing folders; (3) validate and disseminate BDA in order to evaluate mission results; (4) order and supply their own batteries; (5) pick up the TEMIG beacons at Ubon and deliver them to the field; and (6) provide detailed information on each proposed mission to 7/13AF sufficiently in advance to permit coordination with 7AF, the Embassy in Vientiane, and 16 SOS. For its part, the 16 SOS would (1) provide aircrews qualified in the use of the Pave Mace System; (2) flight check the air and ground

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equipment; and (3) install and maintain TEMIG decoders in all aircraft. They would limit 40mm fire to 300 meters and 20mm fire to 200 meters of a friendly position except in an emergency. (As a precaution against their inadvertent destruction by gunship fire, unmanned beacons would be placed no closer than 200 meters to the target.) Finally, ASD was to provide technical support for the entire program.^{95/} These concepts and procedures were later incorporated into a 16 SOS OPLAN which was completed by May 9.^{96/} At about the same time, the installation of decoders in all 18 aircraft was completed.^{97/}

Until standard supply channels could be opened, the 16 SOS OPLAN tasked 7/13AF to (1) maintain accountability for the beacons and retain possession of them until issued to the user (normally CAS); (2) maintain the beacons and provide spare parts; (3) insure that the operators could use the beacons properly; (4) maintain an up-to-date file on the location and status of all beacons; and (5) pass user requests to 7AF and disseminate reports on mission results. Seventh Air Force would frag or divert AC-130s to support Pave Mace operations, collect and analyze data on mission results in order to improve procedures, and establish normal supply channels for the necessary equipment and technical support. The OPLAN also established the airborne tactics and aircrew procedures for Pave Mace operations.^{98/} Although this document was never formally approved, it served as the guide for subsequent missions and became the basis for later manuals and procedures. Given the irregular manner in which the Pave Mace system had been introduced and the problems encountered, the speed

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with which the using units were able to develop a comprehensive concept of employment is noteworthy.

In the meantime, the entire Pave Mace program had become entwined with, and to a certain extent jeopardized by, the reintroduction of Combat Rendezvous.

THE REINTRODUCTION OF COMBAT RENDEZVOUS

Shortly after the first Pave Mace units were deployed to the field, ASD introduced an improved version of the Combat Rendezvous system into SEA. This reintroduction of Combat Rendezvous was based upon several new items of hardware developed as a result of the Lockbourne, SEA, and Puerto Rico tests of 1969-1970. These tests had shown a number of deficiencies in the SST-201X miniponder, the AWG-13 Fire Control System, and the APQ-133 BTR. As a result of these tests, a new FACS, the AYK-9, was developed and installed in all AC-119 and AC-130 gunships. Also resulting from these tests was the development of an improved BTR, the APQ-150, which had greater power, increased sensitivity, and finer tuning than the older APQ-133.^{99/} By the spring of 1971, work on this radar was virtually complete, and it was expected to be available by the end of May. At the same time, Motorola had developed an improved transponder, the SST-119X, with a 50 watt output.

With this new equipment in the offing, ASD resurrected Combat Rendezvous. In order to circumvent the Army's refusal to acquire the UPN-34 in quantity, ASD felt that the best course was for the Air Force to acquire

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its own beacons and distribute them to any interested ground commanders (principally CAS, MACSOG, SF, and, perhaps, a few Army field commanders). Consequently, ASD requested, and received, \$50,000 to purchase 18 SST-119s (eight hand-held units designated TAFSEA Beacon and 10 air droppable units designated SST-125.^{100/} These units, along with a ground test set, were delivered to the Air Force on 14 April and shipped directly to the 8th TFW at Ubon four days later.^{101/} At the same time, a Motorola Tech Rep, Mr. Oscar Staggs, was diverted from Rhein Main AB, Germany, to Ubon to assist in the maintenance of the transponders.^{102/}

Unfortunately, the manner in which the program was handled created considerable confusion and some hard feelings. In the first place, Mr. Staggs' orders incorrectly stated that he was to be a member of the Pave Pronto team--a program which had no connection with either Pave Mace or Combat Rendezvous--and neither he nor Ubon were informed as to the real nature of his mission. The 8th TFW objected strongly to this procedure in a message to 13AF:^{103/}

Positive operational and maintenance control over 8TFW AC-130 gunships is made extremely difficult by arrival of unprogrammed personnel to effect implementation of uncoordinated programs. A typical example was the arrival of Mr. Oscar L. Staggs, Motorola, Inc from Rhein Main AB Germany as directed by ASD/SDY order TD-124, dated 8 April 71. Mr. Staggs' orders contain the following purpose for travel: "To serve as a member of the Pave Pronto gunship team." Mr. Staggs does not know why he is here nor do any of the other members of the team. We suspect his presence has something to do with field/air implanted transponders and side looking

radar. Again request ASD be instructed to utilize PACAF command channels for proper coordination of all programs and modifications involving 8TFW AC-130 gunships. Request command assistance to preclude recurrence and to determine purpose of Mr. Staggs' presence at Ubon.

The second problem arose from the fact that the APQ-133 radar had been removed in late 1970 and the APQ-150 was not scheduled for delivery until the end of May 1971. Even then, it was programmed for installation only in the AC-130 and not in the AC-119. Thus, any employment of the new beacons would have required reinstallation of the APQ-133, yet no such reinstallation had been directed. Since there was no coordination between ASD and PACAF, ASD was unaware that the APQ-133 had been removed and PACAF had no knowledge of the program ASD was trying to conduct. Nor was the situation any clearer to units in the field. General Evans, by now a strong advocate of the Pave Mace/Combat Rendezvous system, made note of this in a message to 7AF: 104/

Confusion at all levels obviously exists over whether or not the AC-119K has an adverse weather capability using an APQ-133/150 radar with an X-band ground transponder. My understanding is that it does but that it was abandoned because of lack of interest by the U.S. Army. There is no desire here to push the use of this system against good advice to the contrary; however, ground forces in northern Laos are very interested in using the capability if it exists. Necessary coordination could be achieved here. When 7AF position is established, request this Headquarters be advised.

[REDACTED]

The final problem was that ASD had used the term Pave Mace/Combat Rendezvous to refer to the purchase of the SST-119X. This created confusion as to whether it was an entirely new program, or whether it included the old X-band/APQ-133 program and/or the TEMIG/Black Crow system. Subsequently, correspondence made it clear that ASD intended to group all IFR offset firing systems under this classification while PACAF considered them as three distinct programs. On 21 April, Hq USAF added to the semantics problem by directing that the term Combat Rendezvous be dropped and that ". . . future correspondence relating to the current project utilize the nickname Pave Mace," without clarifying just what the "current project" included.^{105/}

These problems were the basis for a lively exchange of correspondence between PACAF and ASD. In general, PACAF wanted ASD to coordinate its programs with PACAF before going into the field, for such lack of coordination resulted in a number of problems. For example, PACAF assumed that the new program was simply a revival of the original APQ-133/AC-119 program which had apparently failed. Based upon incomplete information, and in the absence of any prior ASD coordination concerning the revised project, PACAF concluded that:^{106/}

. . . extensive information on Combat Rendezvous indicates little hope that the AC-119K will be successful in the adverse weather role.

[REDACTED]

The message then went on to cite deficiencies encountered during the Lockbourne and Puerto Rico tests, and concluded: ^{107/}

Operational tests to date have been marginally successful and no adverse weather capability has been demonstrated. In view of the inherent system deficiencies, it is apparent that the AC-119 has limited potential in the all-weather close air support role. For this reason, . . . it does not seem prudent to pursue the AC-119K/APQ-133 Combat Rendezvous program.

PACAF had apparently not been informed that: the new program was not the same as the old AC-119K/APQ-133 program; major deficiencies cited had been overcome by modified operator technique, improved equipment, or had been recognized as "no fire" situation; and a close reading of the original Combat Rendezvous results did indeed demonstrate an all-weather capability. Had ASD coordinated the new program with PACAF in advance, these issues could have been resolved. As it was, ASD tried to clarify the situation in its reply of 14 April 1971. This message explained the results of the earlier tests and pointed out that the APQ-150/AC-130 should prove superior in every respect to the earlier program. ^{108/} ASD followed this message with another on 22 April which went into even greater detail and suggested that consideration be given to installing the APQ-150 in the AC-119K as well as in the AC-130. ^{109/}

PACAF was not persuaded by these replies and, on 27 April, restated all original objections while adding new ones. ^{110/}

[REDACTED]

Further study has reinforced PACAF view that AC-119K is not adequately equipped to perform the adverse weather role reliably. ASD comments are substantiated by test reports; however, PACAF judgement is influenced by the following factors.

A. Army refused to certify system after evaluation of Air Force test data. LWL advised USARV as follows: Quote. Recommend system not be used in limited visibility unless confirming position data is provided by a back up sensor device in the aircraft. Unquote.

B. APQ-133 was not tested and certified during AC-119K combat introduction/evaluation. Further, we have no record of the system ever having been employed in actual adverse weather conditions.

C. PACAF files included reports of seven attempts to use the APQ-133 System in SEA. Only three were successful.

D. Former gunship crew members now assigned to PACAF have little confidence in the system. It is the consensus that the APQ-133 provided incorrect information regarding transponder location on approximately 40 percent of sensor alignment check at Ubon.

E. Combat evaluation of Rabet I and Rabet II, programs which used high power F-4 radar in conjunction with ground emplaced transponders, were both unsatisfactory.

F. APQ-133 deficiencies are documented in the minutes of the 3 Mar 1970 conference which reviewed the Puerto Rico test data. Based on APQ-133 characteristics/deficiencies and extensive experience with transponders in Combat Skyspot and Rabet operations it is predictable APQ-133 performance can be no better than marginal.

G. Because APQ-133 was not recognized as an acceptable system by USARV and because it created adverse aerodynamic drag on AC-119K, the APQ-133 was removed from all AC-119K in November 1970 (class I MOD).

The message continued: 111/

[REDACTED]

PACAF is concerned about the manner in which unwarranted interest in AC-119K adverse weather capability has been revived. Under the nickname Pave Mace, recent ASD USAF correspondence has confused the issue. For example, the inference in ref A is that the capability presented by the ASD-5 (Black Crow) and its associated electro-magnetic emitter is the same as that represented by the APQ-150/133 beacon tracking radars. As stated in previous correspondence, we are very interested in the ASD-5 tests being conducted with the AC-130s. However, we do not view this Pave Mace (Black Crow) capability as being the same as the old Combat Rendezvous (radar transponder) program. PACAF does not support further expenditure of funds on AC-119K improvement modification. . . .

PACAF closed noting that ^{112/}

. . . unscheduled visits and unprogrammed modifications create an adverse impact on combat operations. Additionally, such actions do not benefit from the normal decision-making process. Many of the crash programs in recent years were necessitated by the urgency of SEA operations. However, under current policies and conditions it is PACAF position that programs must use established channels and procedures. . . . If there are things we have overlooked, please advise.

PACAF had not been informed of the degree of interest that Hq USAF had in the program. To underscore its interest, it was Hq USAF--not ASD--^{113/} that replied to the PACAF message.

. . . there appears to be varying interpretations of available data which may warrant a meeting of all involved parties. The purpose of this meeting would be to resolve the Air Force position relative to the APQ-133/150 radars, X-band ground transponders and the adverse weather capabilities and limitations of AC-119K. If you agree, we request that you host the meeting at PACAF in the very near future.

Warm regards.

[REDACTED]

PACAF's response assured Hq USAF that its only concern was to avoid confusion between the Pave Mace system and the Combat Rendezvous system. ^{114/}

^{115/}
PACAF then stated:

If, in your view, a meeting of all concerned will serve to clear the air and establish a clearer understanding, PACAF will be happy to host such a conference on 26 May.

When 7AF was informed that a conference was to be held at PACAF, it recalled 7/13AF's earlier proposal for a similar meeting. Consequently, 7AF notified 7/13AF: ^{116/}

Your recommendation that a 7AF Pave Mace Conference be convened has been reconsidered. The conference is scheduled for 1400 hours 17 May in the 7AF DO Conference Room.

The purpose of the conference would be to develop a 7AF position which could then be taken to the PACAF conference.

While this exchange of correspondence had been going on, both Combat Rendezvous and Pave Mace had remained in a state of limbo. No Combat Rendezvous missions had been flown since the new equipment had arrived in theater, and there had been no Pave Mace missions since 18 April. The Motorola Tech Rep was still at Ubon, the TAFSEA beacons had not been deployed to the field, and no APQ-150s or APQ-133s had been installed in the gunships.

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Nevertheless, a great deal of preliminary work had been accomplished. As early as 14 April, 7/13AF, CAS, and the 16th SOS had worked out a basic procedure for a revised Combat Rendezvous program based upon the experience with Pave Mace and earlier Combat Rendezvous experience. After reviewing the available data, it was agreed that most of the earlier problems had been associated with the AWG-13 FCC and with the ground operator. The problems of side lobes and false and intermittent lock-ons were discussed and it was determined that they could be corrected by modifying operator technique. As envisioned by CAS, 7/13AF, and 16 SOS, all ground beacons, whether TEMIG or X-band, would be deployed to prepared sites at known locations and used by English speaking FAGs who were experienced in controlling TAC AIR strikes. Since these sites were normally located on hilltops where all near-by foliage had been removed to permit a field of fire, no problems of signal attenuation were anticipated and there would be ample room to adjust fire. In addition, both the AC-119 and AC-130 had forward looking radars for terrain avoidance and the crews were experienced in maintaining the proper firing altitude and making necessary adjustments for firing into a valley. The group also recognized that the AC-130s would continue to be used primarily in a truck killing role and would be available for troop support only on an emergency basis. Therefore, the Combat Rendezvous program would depend primarily on the AC-119/APQ-133.^{117/} CAS, however, was reluctant to accept the decreased AC-119 TOT which would result from drag caused by reinstallation of the APQ-133 antenna and preferred, under normal circumstances, to sacrifice all-weather capability in return for

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longer TOT. Reinstallation of the APQ-133 would necessitate either one additional gunship each night to make up the lost TOT or the ground forces would have to go without air cover part of the night. Since the prospects of getting an additional gunship were virtually nonexistent due to a shortage of aircraft, the latter situation was likely to prevail and this was unacceptable to CAS.^{118/} Nevertheless, the reinstallation of the APQ-133 appeared to be the best course under the circumstances, and 7/13AF informed 7AF that it was prepared to conduct a combat evaluation.^{119/} However, 7AF postponed any action until after the 7AF conference.

With the prospect of a major conference in the offing, the principal users again met at Ubon to review the program status.^{120/} At this meeting, the 16 SOS Pave Mace OPLAN was reviewed and discussion then turned to Combat Rendezvous. After inspecting the equipment stored at Ubon, it was agreed that the Motorola Tech Rep should be prepared to move to NKP to assist in the reinstallation of the APQ-133 BTR and to conduct a training program for maintenance men and aircrews. At the same time, the 18 SOS (AC-119K) would prepare an OPLAN for conducting the combat evaluation. Final details for coordinating user requests through 7/13AF were worked out with CAS and it was agreed that the X-band beacons should be transferred to Ugon where they would be turned over to CAS. All of these actions, however, would await the outcome of the 7AF Conference.^{121/}

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THE SEVENTH AIR FORCE CONFERENCE

Events were now beginning to move rapidly. So rapidly in fact, that 7AF needed more time to conduct its own evaluation and develop a well documented position. Consequently, 7AF requested PACAF to delay its conference pending completion of 7AF's own evaluation.^{122/} PACAF concurred and rescheduled the conference for 20 July.^{123/} Seventh Air Force then postponed its own conference until 27 May.^{124/} In the meantime, AFSC had suggested a possible search and rescue (SAR) role for Pave Mace.^{125/} 7AF replied that any such consideration should await the system's further evaluation in a direct air support role. Seventh Air Force did suggest, however, that MAC and TAC be requested to conduct a feasibility study, and determine employment concepts and training requirements for both SEA and world-wide application of Pave Mace in a SAR role.^{126/}

When the 7AF Conference finally convened, it proved to be the turning point in the entire program. For the first time, representatives from both of the gunship squadrons, CAS, the American Embassy in Vientiane, 7/13AF, AFSC, and 7AF met together to review all of the available data and work out a total program. The first step was to survey the status of equipment on hand. As of 27 May, six AC-130s had TEMIG decoders installed. However, one of these units had malfunctioned and there were no technical manuals available on the repair and maintenance of the decoders. The remaining units could be transferred from one aircraft to another if needed to meet a fragg mission. Seven APQ-133 BRTs were stored at NKP and each could be installed in six hours. However, there were no X-band

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beacons available at NKP to align the BTRs, and all ground boresighting equipment was stored at Phan Rang. The APQ-150s were scheduled to arrive at Ubon in June but there was no firm schedule for their installation in the AC-130s. As for ground beacons, CAS already had six TEMIG Is and a single TEMIG II; ten miniponders, left over from the original Combat Rendezvous program, were stored at TSN; eight TAFSEA beacons (SST-119X) and ten SST-125 air droppable beacons were at Ubon; and a small number of UPN-34s, also left over from the old Combat Rendezvous program, were in the hands of various ground units. However, none of these beacons could be maintained by organic maintenance personnel since no technical manuals had been provided.^{127/}

AFSC was requested to provide an installation and check out schedule for the APQ-150. Seventh Air Force also wanted to know where and by whom maintenance would be performed; when technical manuals would be available; and where, when, and how maintenance and operator training would be accomplished. AFSC was additionally asked to provide technical data; operation and maintenance manuals; associated ground equipment (AGE); and information on disposition, accountability, supply, and maintenance support of all X-band and TEMIG beacons. 7AF requested guidance on security classification and all information on CONUS testing. Finally, they sought to determine whether consideration had been given to developing a retractable antenna mount for the APQ-133.^{128/}

As an interim step, the X-band beacons at Ubon would be turned over to CAS for issue to units in the field. CAS, in turn, would maintain a current listing of the location, identification, call sign, and radio

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frequency of all beacons (X-band and TEMIG). This listing would be constantly updated and passed to 7/13AF for distribution to 7AF and to the gunship squadrons. Special care would be taken to identify beacons which may have fallen into enemy hands. In such cases, gunships would not strike the compromised beacon unless it was specifically validated for destruction by the U.S. Embassy, Vientiane. It was also decided that the SST-125 would not be air dropped. Instead, the self-destruct mechanism would be removed and the beacon infiltrated and exfiltrated with ground units. ^{129/} To solve the problem of beacon supply, the conference directed 7AF (DM) to coordinate with ASD on introducing X-band beacons into regular supply channels.

In order to gain additional data to support a 7AF position on off-set firing, it was decided to conduct and document a combat evaluation of both systems. Since Hq USAF had already stated that both systems were combat ready, the evaluation was to be used to develop procedures and to determine operational capabilities and limitations. The shortage of aircraft and the many mission requirements already levied upon them precluded any nontactical sorties, so the evaluation would have to be conducted using existing fragged missions. At the same time, operator and maintenance ground schools would be established at Ubon (Pave Mace) and NKP (Combat ^{130/} Rendezvous) to familiarize air and ground crews with the equipment.

AC-130s had been flying in support of ground operations in northern Laos since 23 May and it was decided to use these missions for an intensive five-day Pave Mace evaluation beginning on 30 May. A complete evaluation

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of Combat Rendezvous was deferred until installation and check out of the APQ-150 had been completed. In the meantime, a limited evaluation would be conducted using the AC-119. In view of CAS objections to lost TOT, a general reinstallation of APQ-133s was not directed.^{131/} Instead, sets were installed in four AC-119s at Da Nang for use in the northern Republic of Vietnam (RVN).^{132/} In addition, all necessary boresight and alignment equipment would be moved to NKP where the APQ-133s would be peaked and readied for installation if the weather in northern Laos deteriorated to the point where IFR firing was required. In this case, CAS would provide 7AF with 24 hours advance notice of IFR support requirements in order to permit APQ-133 installation and fragging of the mission.^{133/} In view of the limited experience with both systems and the ROE limitations, it was decided to conduct all testing under VFR conditions except in an emergency when the ground commander was willing to accept responsibility for short rounds. Voice contact was to be maintained at all times.^{134/} At the same time, 7AF decided to ask MACV to modify the ROE to permit gunships to use Pave Mace/Combat Rendezvous for support of troops-in-contact in RVN under IFR conditions. This request was subsequently prepared, but its submission to MACV was postponed until after the PACAF Conference.^{135/} To implement these decisions, 7AF issued OPLAN 796 (Combat Rendezvous) and 797 (Pave Mace) on 11 June 1971.^{136/}

On 8 June, ASD provided 7AF with the information requested at the 27 May conference. In addition to information on CONUS testing, security classification, and accountability of beacons, the message stated that

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the APQ-150 and associated publications would be shipped as soon as qualification testing was completed. An installation and check-out schedule could be established at that time. The Motorola Tech Rep would be available to provide assistance and to train standardization/evaluation personnel. Ground boresighting was to be accomplished by aligning the radar with the IR or NOS but was not to use a ground beacon due to the possibility of multi-path reception. Once airborne, radar alignment, lock on, and tracking would be verified using a ground beacon at a known location. This was essentially the procedure already used with the Black Crow. A ground test set and technical manuals had already been provided for the X-band beacons, but until an organic repair capability was established, beacons were to be returned to AFSC for repair or disposal. The maintenance concept on the TEMIG beacons was simply to replace the batteries. If that did not work, the TEMIG II would be discarded and the TEMIG I returned to the NWL for repair. Consequently no test equipment, technical manuals, or organic maintenance capability would be provided for these beacons. ^{137/}

In regard to a retractable APQ-133 radome, AFSC felt that it was an excellent idea but suggested that 7AF should state a definite requirement through regular materiel channels for a Class V modification or forward a Combat ROC so that the System Project Officer (SPO) could take action. ^{138/}

COMBAT EVALUATION

In the meantime, combat evaluation of both systems was already under way. An unofficial evaluation of Pave Mace had actually begun on 23 May

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when AC-130s were fragged to support Boum Long (LS-32), where several Laotian FAGs were equipped with TEMIG beacons. However, none of the eight missions flown between 23 and 27 May were able to pick up the beacons due to weak batteries. They did provide support, however, using their other sensors. Following the 7AF Conference, the TEMIG beacons were returned to Ubon where it was confirmed that the problem was with the batteries and not with the beacons themselves or with the airborne equipment. By 30 May, these units were returned to LS-32 along with additional batteries and formal testing began the following night.^{139/}

The first mission established beacon and voice contact with the FAG as soon as it arrived on station. The signal remained strong throughout the mission and the gunship retained a positive lock on for its entire one hour and forty-five minutes on station. Due to the experience level, coordinated air/ground procedures were still unrefined and some time was lost to this factor; nevertheless, the FAG reported that all firing was "Number 1" and on target.^{140/} The mission originally scheduled for the night of 1 June was cancelled but then reactivated prior to the scheduled take off time. In the meantime, an AG-130 had been diverted from Steel Tiger. Weather was 7/8 to 8/8 overcast but the ground situation was so serious that the FAG elected to use the gunship anyway. This was the first actual combat all-weather employment of the Pave Mace system. Voice and beacon contact were normal and the gunship fired at a variety of targets as directed by the FAG. According to the mission report, an unknown number of the enemy were killed or wounded, and an undetermined

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amount of supplies was destroyed. ^{141/} Of far greater significance was the fact that the gunships fire -- delivered through a solid deck of clouds -- so confused the enemy that he broke off his attack.

When the second gunship arrived, voice contact was established but the beacon signal was too weak to be used. ^{142/} As a result of these missions, additional batteries were delivered to LS-32 and 7/13AF urgently requested an immediate shipment of 50 batteries to be followed by 50 additional batteries per month. ^{143/} On 2 June, one sortie was fragged but initially was unable to establish beacon contact. After instructing the FAG to change batteries, a positive ID and lock on was achieved. Weather this time was a solid overcast at 2,000 feet, but with the confidence gained from the previous night's experience the FAG did not hesitate to use the gunship on targets ranging from 400 to 1,000 meters. The only reported results of this mission were the FAG's comments of "very good" and "number one" after each firing pass. ^{144/} Missions were also flown on 3 and 4 June. Although the weather was a solid overcast on both occasions, the missions were successful and no problems were encountered. On the last mission, the only positive BDA of the series -- three secondary explosions -- was recorded. ^{145/} This BDA, however, was insignificant compared to the fact that the enemy attack on LS-32 was repulsed and that the Pave Mace system had worked as intended in a critical situation, under adverse weather conditions when no other system was available. CAS later credited these missions with saving Boun Long. ^{146/}

In response to an inquiry from 7AF concerning these missions, 7/13AF submitted the following report: ^{147/}

[REDACTED]

The following answers for the Pave Mace evaluation were derived from debriefing the two ground FAGs that have utilized the 'TEMIG' BEACON/offset capability for the past ten days at 'hunters' location, LS-32. At present, these two FAGs are the most experienced in Pave Mace operations, having controlled the gunships on six separate nights in varying terrain, targets, and weather conditions.

A. (Question) Do you consider Pave Mace capable of all weather operation? (Answer) Pave Mace has proven very accurate in IFR conditions. Five of six nights hunter reported weather conditions between 1500 and 3000 ft overcast and the gunships still were able to effectively strike.

B. (Question) Do you think it possible to fire without voice contact? (Answer) Both FAGs agree that voice control is necessary during close support against enemy ground assaults; however, the system could be utilized without voice control in specialized cases, e.g., trucks, storage areas, etc.

C. (Question) How close to friendlies would you fire using Pave Mace beacon/offset techniques if IFR and no voice contact established? (Answer) Hunter has offset strikes as close as 300 meters and would not hesitate to use the system at closer ranges. Individual situations would determine proximity of firing during IFR and no voice contact situations. 7/13AF additional comments to this question are: if the FAGs are fully trained, the proper beacon code appears on initial contact, and considering the advertised 20 meter CEA capability of the gunship then there is no reason the gunship cannot fire within the parameters/capabilities of the 'TEMIG' beacon. If, however, a positive safety margin is necessary then 200 meters minimum is recommended and the direction of fire should not be toward or over the heads of friendlies. (If it should be along or parallel to the firing line).

D. (Question) Other comments based on Pave Mace experience to date? (Answer) The major criticism of Pave Mace is its limited range capability (1000m), but as a close range support weapon, Pave Mace has proven its value. 7/13AF would like to summarize by stating the system is very accurate, valuable, and should be exploited to its fullest. Additionally, the type war we are fighting in Southeast Asia warrants one or two gunship wings to fully support the ground troops and conduct an interdiction

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program at the same time. With the monsoon seasons experienced in Southeast Asia, an all weather capability is a definite requirement and to date this is the only one capable of providing close support to the ground troops during IFR and at night.

In addition to these missions flown in support of LS-32, a number of unscheduled missions were flown in southern Laos. None of these missions were successful due to battery failures and a lack of trained beacon operators. 148/

Although the test officially ended on 5 June, Pave Mace missions in Barrel Roll continued sporadically throughout June and July. By 14 July, a total of 19 missions had been flown. On one of these missions, a computer malfunction not associated with the Pave Mace system prevented the gunship from firing. Four other aircraft encountered problems due to weak batteries, but three of these aircraft were able to complete their missions once the batteries had been changed. The remaining 14 missions were completely successful. Altitudes varied from 5,500 feet (using 20mm guns) to 9,500 feet (using 40mm guns). Beacon acquisition was from 1 to 10 nautical miles (NM) with an average of three NM. Time on target averaged 1.3 hours, during which the gunships expended an average of 3250 rounds of 20mm ammunition and 350 rounds of 40mm against 15 troop concentrations or TICs, nine gun emplacements, four supply areas, and one truck at ranges from 200 to 1000 meters. Weather which was VFR on only three occasions, 4/8 or less cloud cover on six nights, and 5/8 or greater on 10 nights) limited BDA. Seventeen missions reported results not observed (RNO), while one mission recorded three large secondary explosions and the remaining 149/ missions reported a total of three small secondary explosions. Ground

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assessment of the results was equally imprecise since the defenders were reluctant to expose themselves to enemy fire by going out to count bodies. To these friendly troops, the fact that all enemy attacks were repulsed was sufficient proof of the system's effectiveness.

Seventh Air Force was naturally anxious for more definite information and pressed all parties to make every effort to obtain more precise BDA. ^{150/}
^{151/}
However, as 7/13AF noted:

Concern has been expressed that gunships BDA is not always available. However, this is not an adverse reflection of the true mission success. Recently two friendlies were killed attempting to obtain BDA for a Pave Mace mission. Consequently further attempts were abandoned and a decision was made that future BDA would be submitted when available.

The following BDA for night gunship operations between the period 9-15 June 1971 is retransmitted for your information.

A. During this seven day period night gunship operations in the vicinity of LS-32 have resulted in twelve (12) enemy (NVA) KBA by body count. Three (3) enemy bodies were recovered within two hundred (200) meters of the southwest perimeter of the 'TANGO OSCAR' pad on the morning of 10 June. Blood trails in the area indicated that additional enemy were killed or wounded and subsequently removed from the area prior to the sweep operations.

B. Five (5) enemy (NVA) bodies were recovered from the northwest slope of the 'VICTOR ECHO' pad on 11 June. Four (4) additional enemy (NVA) bodies were recovered from the northwest slope of the 'VICTOR ECHO' pad on the morning of 14 June. However, it is not certain on which night they were killed. The bodies that were in the vicinity of strikes on 12/13 June appeared to have been killed by exploding rounds [fired] by gunships.

[REDACTED]

C. On 15 June night gunships fired on an enemy TPC. Subsequent sweeps of the area revealed numerous blood trails on the morning of 16 June. The BG Commander believes that a large enemy unit had been staging in that area to launch attacks against the 'TANGO OSCAR' pad. Night gunship strikes however thwarted the attack before it could develop. Spectre 01 put a strike into what appeared to be a staging area for an attack to be launched against the 'VICTOR ECHO' pad. Numerous blood trails were discovered the following morning.

During these missions, several problem areas were identified. The most serious problem was the short life of the TEMIG batteries under continuous use. This was corrected by keeping the FAGs supplied with an adequate number of spares. A second, minor problem was the frequent movement of FAGs from one position to another without informing 7/13AF. Gunships were thus fragged to one location only to find that the FAG was no longer there. This resulted in much lost time as the gunship tried to locate the FAG's new position.^{152/} CAS and 7/13AF tried to maintain current records on all FAG locations but were not always able to do so because of the fluid tactical situation in Barrel Roll. The FAGs also noted Pave Mace's 1,000 meter range limit and preferred to engage the enemy farther out than that. However, as a close-in, all-weather system, Pave Mace was recognized as being without equal.^{153/}

Although the TEMIG I automatically provided target identification, range, and bearing, the FAGs felt that voice contact was necessary during close-in support against ground assaults. However, they felt that such contact would not be necessary in attacking more distant targets such as trucks and storage areas. The 16th SOS expanded upon this point in a

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message to 7AF:

The Pave Mace system is capable of all weather operations with or without voice communications. However, it must be realized that without voice communications to adjust the impacts, the probability of hitting small targets is practically nil, especially with large offset distances. Communications with the beacon operator would not be a factor in determining the offset distance under IFR conditions if the beacon operators were thoroughly indoctrinated to commence initial firing at greater distances and walk the impacts into the desired target areas. No restrictions need be imposed when voice contact is not available. If targets are to be attacked without voice contact the beacon and the area will require prior validation for gunship operations and a location of friendly positions would be required.

During the combat evaluation, the closest strike to friendly forces was 200 meters, but neither the FAGs nor the aircrews foresaw any problem using the system at its minimum range of 100 meters. If, however, a positive safety margin was desired, it was agreed that 200 meters was adequate if the direction of fire was not toward or over the heads of the friendly forces. ^{155/}
Based upon this information, 7AF was prepared to go to the PACAF conference with the position that Pave Mace was a fully operational all weather system. ^{156/}

In comparison with the overwhelming success of the Pave Mace system, the Combat Rendezvous evaluation, which did not get underway until 3 June, encountered a number of problems. Following the 7AF Conference, APQ-133s were reinstalled in four AC-119Ks at the 18 SOS Forward Operating Location (FOL) at Da Nang. Ground crews and aircrews were given a quick refresher course, and a briefing was presented to various Army units in MRs I and II of RVN. A number of these units already had X-band beacons which had been

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acquired from various sources during the original Combat Rendezvous Evaluation. Seventh Air Force also had a number of sets (SST-201 mini-ponders, UPN-34s and SST-119 TAFSEA beacons). These sets, along with the associated technical manuals were turned over to the Army for use by selected reconnaissance teams and for emplacement at Da Nang, Camp Eagle, FSB C-2, and FB-5. Initial testing was scheduled to be conducted at FB-5 using a SST-201 miniponder. Unfortunately, this particular test was plagued by problems. Bad weather prevented beacon delivery until 3 June and then a series of scheduling and coordination problems developed. Since all of the test missions were flown in addition to the normal frag, and were executed at the discretion of the FOL commander in coordination with the FB-5 commander, conflicts occurred.^{157/} The BTRs only had a 40% in-commission rate.^{158/} These problems resulted in frequent aircraft changes, no BTR aircraft in commission, all aircraft committed to other missions, or aircraft unable to be turned around in time to meet the Army requests. In other instances, when aircraft were available, the ground commanders requested support only infrequently, due to an absence of activity and because the weather was VFR and VNAF AC-47s or AC-119Gs were used. On some occasions, the AC-119Ks were diverted to other targets or could not be cleared into the area due to local conditions such as severe thunderstorms or heavy artillery fire. These problems had a direct impact on maintenance crews and schedulers.

When the aircraft did get airborne, they were sometimes unable to perform an airborne alignment check due to a weak or inoperative test beacon or because of extraneous X-band transmissions in the airfield area,

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which caused interference and false lock-ons. ^{159/}

On several occasions, when the the aircraft were cleared into the area, the ground beacon was weak or unreliable due to improper handling by the ground forces or as a result of weak batteries. This was a significant problem because there was no way to field check the beacon before the aircraft arrived overhead and there were no provisions for maintenance or repair of the beacons either in the field or at Da Nang. In other cases, the beacon was too close to artillery pieces or other metallic objects, resulting in side lobes and multipath interference. At other times, the hand held compass was too close to the beacon (which contained a powerful magnet) or to other metallic objects giving false compass readings. On the three occasions when al of these problems were overcome and a positive lock on was achieved, other problems were encountered. The fire control computer malfunctioned on one mission, the gunship was not cleared to fire due to nearby friendly forces on the second, and, on the third, the target was beyond the range of the computer offset. ^{160/}

As of 15 June, there had been no successful Combat Rendezvous missions, and 7AF decided that it was time to restructure the program. As a first step, additional briefings and a simplified set of instructions were given to the ground forces. At the same time, Combat Rendezvous missions were included in the regular frag and both I and II DASCs were instructed to expend the missions whenever possible with beacon equipped units even when there was no enemy action. ^{161/} Subsequently, 13 missions were flown between 20 June and 14 July. Weather was VFR on three of these occasions, 4/8 or

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better on four occasions, and 5/8 or worse on three missions. In four instances, the ground beacons malfunctioned; in four others, the airborne equipment failed. The remaining five missions were able to expend an average of 2220 rounds of 7.62mm and 1420 rounds of 20mm ammunition at troop concentrations, bivouac areas, and gun emplacements, ranging from 200 to 1,000 meters from the beacon. Beacon acquisition and lock on averaged 2.3 NM, with a maximum of 7 NM. Firing altitudes varied from 2,500 feet (7.62mm) to 5,500 feet (20mm), and average TOT was 1.1 hours. Although no BDA was reported on any of these missions, this was attributed to weather and the inability of the ground forces to inspect the target area.^{162/} Nevertheless, the ground forces were very pleased with the results of those missions which were successful. On 14 July, for example, the 5th Infantry Division reported:^{163/}

When the aircraft was able to lock on to the transponder signal, the system proved to be an accurate and easily controlled fire support system.

Between 15 July and 24 August, another 15 Combat Rendezvous missions were flown with results which confirmed the earlier data. Eight missions were successful, four failed due to ground beacon malfunctions, and three failed due to airborne equipment malfunctions.^{164/}

In the meantime, the 16 SOS was beginning to receive the APQ-150, which promised to provide an improved Combat Rendezvous capability. The first set was successfully flight checked on 8 July, and within a week all aircraft were equipped with the new radar. However, a series of maintenance problems prevented the system from being employed in combat prior to the PACAF Conference. The first problem encountered was with the ground beacon

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(an SST-181) which was used for airborne alignment checks . Due to continuous use, this unit had become unreliable. This was corrected by replacing the battery with a constant power supply which returned the set to peak performance. The second problem stemmed from the inexperience of maintenance personnel. This was overcome by the Motorola Tech Rep, who set up an OJT program. Finally, there was a lack of communication between operations and maintenance on reporting system malfunctions. To correct this problem, a simplified work sheet was developed which helped to maintain an accurate record of system performance and malfunctions. As these problems were worked out, the system reached 83% reliability, which was identical to that of other sensors on the aircraft.^{165/}

Based on this data, 7AF believed the Combat Rendezvous system was combat ready. System reliability and maintenance were recognized to be continuing problems, but in no case did system malfunction endanger friendly forces and, when the system worked, it added a much needed dimension to gunship capability.

THE PACAF CONFERENCE

The PACAF conference, which met 20-22 July, established a firm program for the system's operational employment. After days of deliberation, the Conference confirmed that:^{166/}

Tests and operational experience conducted to date have proved the feasibility of the concept to employ gunships equipped with Pave Mace equipment and X-band beacon-tracking radar in the adverse weather close air support role.

[REDACTED]

However, the Conference also felt that, in view of the Army's lack of support, there was "an obvious need for more thorough documentation of gunship capabilities and limitations."^{167/}

Specifically, the conference regarded the Pave Mace system as completely operational, having been successfully employed under actual IFR conditions in support of friendly forces on numerous occasions. Therefore, it was recommended that 7AF issue the necessary CROC to have Pave Mace decoders installed in all AC-130s and to establish complete support requirements including instructions on capabilities, limitations, and operator techniques for optimum utilization in a close air support role. It was also felt that the full potential of the system had not yet been developed. Consequently, the conferees suggested a joint Air Force/Army evaluation to determine the full spectrum of operational capabilities and limitations. Along the same lines, it was recommended that the forthcoming Pave Spectre Operational Testing and Evaluation (OT&E) be expanded to include continued development of the Pave Mace system.^{168/}

The Conference felt that the APQ-150 (despite the absence of a conduct test) offered a reasonable assurance of satisfactory performance and should be included in the Pave Spectre OT&E, to be followed by a complete combat evaluation and documentation. As for the APQ-133, it was recognized as an accurate and effective system, but its unreliability and maintenance problems severely limited its all-weather capability. In view of the continuing U.S. withdrawal -- including the possible transfer of AC-119Ks

[REDACTED]

to the VNAF--and the requirement for reliable all weather support of friendly forces, it was recommended that the APQ-150 be installed in the AC-119K. To accomplish this, 7AF was requested to determine the VNAF requirement for an X-band capability and issue the necessary CROC. Simultaneously, Hq USAF was asked to conduct a cost effectiveness study of the proposed modification. The Conference also considered the possibility of installing the Black Crow system in the AC-119K. However, considerations of airframe modification, impact on aircraft performance, and the possibility of compromising Black Crow technology in the event of transfer to the VNAF, militated against this proposal.^{169/}

The key element in the entire Pave Mace/Combat Rendezvous system was recognized to be the ground transponder. The TEMIG beacons seemed to be performing satisfactorily and follow-on models promised even better performance if the problems of supply and maintenance could be overcome. Of the X-band beacons, the SST-201X was generally recognized as inadequate due to its low power output and short battery life. The UPN-34 and UPN-25 were definitely superior but suffered from the absence of built-in test circuitry. However, since one beacon could be used to check another, it was suggested that two units be deployed together with one serving as a field check unit and as a back up transponder. The TAFSEA beacon and the SST-125 air droppable units were not discussed since they had never been actually employed in combat, but the problem of field checking applied^{170/} equally to these units.

The principal problems, however, continued to be the Army's lack of support, inadequate maintenance, and an insufficient supply of ground

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beacons. Because of these factors, the ground forces had not received extensive training in the use and care of the beacons with the result that they were subject to rough handling and improper emplacement. Consequently, the beacons had frequently failed in combat situations. This problem was aggravated by failures to introduce the beacons into normal supply channels and to provide for routine preventive maintenance of testing. Instead, the beacons were maintained on an ad hoc basis by various Air Force and Army units. Since USARV cooperation could not be expected in overcoming this problem, it was suggested that the beacons be introduced to the Army and ARVN through the Air Liaison Officers (ALOs), who would also conduct an education program and provide data on operations and maintenance of TEMIG and X-band beacons as well as on gunship procedures and capabilities. In the meantime, it was recommended that the USAF provide necessary maintenance support until the ground forces developed confidence in the system and began to procure and maintain beacons on their own. ^{171/}

Gunship operations, tactics, and techniques--as outlined in TAC/PACAF Manual 55-249--appeared to provide adequate guidance for all weather operations with only minor modifications. However, the lessons learned during Lam Son 719, where the gunships all weather capability was not employed, suggested that AFM 2-5 required updating to include a world-wide role for gunship close air support and to define gunship adverse weather capability. In the meantime, 7AF was directed to submit its proposed ROE change to MACV for approval. ^{172/}

[REDACTED]

Finally, the SAR application of the Pave Mace system was reviewed. Since the initial AFSC inquiry in May, 7AF had maintained close contact with MAC and TAC on the possible use of Pave Mace in a SAR role. These agencies in turn, had completed most of the theoretical ground work and were ready to conduct a test program. The PACAF Conference endorsed this proposal and suggested that the installation of a simplified Black Crow system on an HH-53 be investigated and that a combined AC-130/HH-53 test program be conducted by MAC/TAC/AFSC as soon as feasible. ^{173/}

Subsequently, many of the PACAF recommendations were implemented. Pave Mace decoders were installed on all AC-130s and both this system and the APQ-150 were included in the Pave Spectre programs. In addition, improvements in fire control computer software permitted the gunship to employ variable bank angles and accept offset information up to 1,000 meters. At the same time, a new TEMIG I which could designate targets out to 2,000 meters* was introduced along with two entirely new beacons, the TEMIGs III and IV. Beacons were eventually introduced into the Air Force inventory, but it was not until early 1972 that they began reaching the theater in quantity. Offsetting these gains somewhat was the complete failure to interest the Army in a joint test program. Although the Air

*In practice the system was never employed beyond 1500 meters. The limiting criterion was the physical impossibility of tracking the beacon while it is outside the gunship attack orbit. Beyond 1500 meters, the aircraft will fly over the beacon and block out the signal to the tracking antenna.

[REDACTED]

Force continued to supply and maintain X-band beacons, it was deemed inadvisable to use the ALOs to introduce the transponders into the field without Army approval. Instead, the Air Force continued to cooperate closely with CAS which was enthusiastic about the program and which continued to use the system and to support the Air Force position. After reviewing the pros and cons of modifying the AC-119K to include the APQ-150 and/or Black Crow, 7AF decided that expected airframe life and limited aircraft capability would not warrant the expenditure of funds on these projects. Perhaps the most significant achievement was the ROE change which was approved in late August and incorporated into the 7AF operating rules on 4 Sept. ^{174/} According to these rules: ^{175/}

- A. A successful inflight sensor alignment and computer offset check will be accomplished.*
- B. Radio contact and verbal clearance to fire will be confirmed by the ground force commander or FAC.*
- C. A positive sensor track and normal system operation will be confirmed.*
- D. Fire only at the designated target, but no closer than 100 meters from the friendlies if the target area is VFR or 200 meters from friendlies if the target area is IFR.*
- E. Do not fire when the gunship heading is within 30 degrees of perpendicular to either end of the friendly target line.*
- F. All related operating procedures and regulations of a more restrictive nature will be complied with.*
- G. Deviation from any of these requirements is authorized only if an emergency situation exists and the ground force commander or FAC accepts responsibility for "short rounds."*

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To these rules, the 18 SOS added the stipulation that the ground commander assume responsibility for short rounds any time 20mm fire was used within 200 meters of a friendly position even under VFR conditions. The rules were further modified on 17 September to require only periodic alignment checks if the crew could verify that no significant changes had occurred since the last in-flight check. This change permitted an increased TOT. ^{176/}

While all of this activity was taking place in SEA, work on the SAR application of Pave Mace was continuing in the CONUS.

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CHAPTER III
COMBAT EMPLOYMENT

KREK/TAY NINH

With the conclusion of the PACAF conference, the Pave Mace/Combat Rendezvous program acquired a new status. However, although an occasional Combat Rendezvous mission was flown, continued Army indifference effectively prevented the extensive application necessary to fully exploit the system. Following the end of the siege of Boum Long in early July--and for the remainder of the year--AC-130s were rarely used in Barrel Roll. This was due in part to the withdrawal of most AC-130s from the theater to undergo modification and IRAN in preparation for the coming Commando Hunt VII interdiction campaign. At the same time, General Vang Pao's irregular forces were now on the offensive and--since the abortive mission in Steel Tiger in April--no consideration had been given to an offensive application of the Pave Mace system. Instead, the system was used exclusively for the defense of fixed sites. As the campaign progressed and enemy pressure on Vang Pao remained light, 7AF felt that the occasional AC-130 dispatched to Barrel Roll could be better employed to kill trucks rather than continuing to support troops. As was the case in Vietnam, this infrequent use of the system caused a marked decrease of interest, especially as the annual turnover in personnel brought in new people who were not familiar with the earlier work and who quickly became preoccupied with the immediate situation. In fact, the entire program was in imminent danger of being ended simply by

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lack of use; had it not been for a sudden shift in the ground war and the efforts of Major General Alton D. Slay, the recently arrived 7AF DO, Pave Mace utilization may well have ended.

An NVN offensive in the Krek/Tay Ninh sector was the immediate cause of the dramatic revival of the Pave Mace/Combat Rendezvous. On 26 September 1971, the NVA attacked ARVN positions just east of the Cambodian town of Krek, causing the ARVN to withdraw in disorder. As the situation deteriorated, it became apparent that the enemy had launched a full scale offensive which might carry him all the way to Tay Ninh. In response to an urgent request from the Army's Third Regional Assistance Command (TRAC), 7AF mounted a major air campaign against the enemy. Between 26 September and 25 October, the USAF flew 904 VFR strike sorties; 193 Loran and 203 Combat Skyspot all weather strikes; and 85 B-52 sorties. The VNAF added another 1,355 day fighter sorties. During the month-long operation, the enemy lost 2,113 killed, of which 1,234 were credited to USAF and VNAF air strikes. According to TRAC, this effort was instrumental in breaking the enemy drive and forcing his withdrawal to Cambodia. ^{177/}

Throughout the operation, generally unfavorable weather limited VFR delivery and the safety requirements for IFR delivery (a minimum of 3,000 meters from friendly positions) prevented employment of TACAIR in support of TICs. The circumstances presented an ideal opportunity for the application of the almost-forgotten Pave Mace/Combat Rendezvous systems. General Slay had become familiar with the system while serving in AFSC and recognized its application to the present situation. Almost single handedly, he infused new life into the all-weather gunship program. On 29 Sept, both

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gunship squadrons were alerted to the possibility of all-weather close air support operations and instructed to peak up their equipment and review their IFR procedures.^{178/} Later the same day, two AC-119Ks, along with their crews and four maintenance men, were deployed from Da Nang to Tan Son Nhut (TSN) to support the operation. At the same time, Gen Slay gathered every UPN-34, SST-125, and TAFSEA beacon, and personally delivered them by helicopter to various fire support bases--Pace, Nihn Hoa, Krek, Alpha, and Ketum--along with instructions on their combat employment.^{179/}

Throughout the operation, the AC-119K continued to be plagued with a series of problems. The principal problem was one of support. The initial deployment was planned for a three day period and only four maintenance men were sent. Support facilities at TSN were extremely limited and 20mm gun maintenance was unavailable. Spare parts for the aircraft, radar, and guns had to be sent from Da Nang.^{180/} As the TDY was progressively extended, the maintenance personnel were simply unable to keep pace with the work load. During the last seven days of the operation, one of the APQ-133s became inoperative and could not be repaired at Tan Son Nhut. As a result of these problems, only 10 AC-119K missions were flown during the operation and only one of these expended using the Combat Rendezvous system. On the remaining missions, there were no targets within the 1000 meter limits of the gunship FCC or the weather was VFR permitting the use of other sensors.^{181/}

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In comparison to the AC-119K Stingers, the AC-130s, which were able to operate out of their home base at Ubon, encountered no significant problems and struck numerous targets ranging from 500 to 1000 meters from friendly forces. General Slay personally directed the entire operation so that gunship sorties complemented TACAIR and B-52 strikes to provide a continuous screen for the ground forces. Because of this complete integration of Air effort--and the inability of the ground forces to precisely determine enemy casualties--there was no way to break out BDA by single mission or type of aircraft. However, the overall effect completely thwarted the enemy's drive. The effectiveness of this operation was noted by the Commander, TRAC, in a letter to General John D. Lavelle, Commander, 7AF: ^{182/}

The biggest surprise to the enemy was the efficiency of our all weather support. The enemy obviously counted on the prevailing bad weather to limit our air fire power, and he couldn't have been more wrong. Through General Slay's personal assistance with equipment, people, and advice, we were able to integrate direct gunship support with LORAN and SKYSPOT radar directed strikes, back them up with B-52 bombing, and provide a volume of all weather, around the clock air fire power that exceeded anything in my previous experience.

ZULU CHARLIE

The second employment of Combat Rendezvous came on 19 November when four AC-130s provided all night support to an Army unit in the A Chau Valley. The army unit, call sign Zulu Charlie, was surrounded by an estimated enemy battalion and was under heavy attack from mortars, small arms, and hand grenades. In response to this tactical emergency, Spectre 06

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was diverted from an armed reconnaissance mission in Steel Tiger. When the gunship arrived over the friendly position, it found a solid under-cast from 1,000 to 7,000 above ground level (AGL). Fortunately, Zulu Charlie had an SST-201 miniponder and the gunship quickly locked on to its signal. After establishing voice contact, the gunship began firing at targets as close as 30 meters from the friendly position and never more than 200 meters away. At times, the gunship's fire was so close to the friendly position that the explosions from its own ordnance were clearly audible to the aircrew through the ground commander's radio. Although the ground commander had accepted responsibility for short rounds, the fire was so accurate that there was no danger to the friendlies. In all, Spectre 06 expended 500 rounds of 40mm and 3,000 rounds of 20mm ammunition during its one and three-quarter hours over target, killing and wounding an unknown number of enemy, and producing two secondary explosions. ^{183/}

With its fuel dangerously low, Spectre 06 was replaced by Spectre 07, which had also been diverted from Steel Tiger. This gunship also picked up the beacon signal and remained locked on for two hours and fifteen minutes, during which time it expended all 640 rounds of 40mm ammunition and 1960 rounds of 20mm. Spectre 07 fired within 50 meters of the friendly position and was credited with 18 killed, 60 wounded, and four secondary explosions. When Spectre 16 replaced Spectre 07, it began to experience difficulty in tracking the beacon, which was becoming weak due to the constant battery drain. After one hour the beacon signal became

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unusable and the gunship ceased firing, having expended 332 rounds of 40mm ammunition. By this time, the enemy attack had been broken and Zulu Charlie was receiving only occasional harassing fire. Nevertheless, Spectre 16 remained on station for another 30 minutes until replaced by Spectre 01. When Spectre 01 arrived, the ground beacon was completely unusable but the gunship nevertheless remained on station relaying radio calls from Zulu Charlie to his home base. Presumably, the enemy did not know why Spectre 01 did not fire. Perhaps its mere presence coupled with the punishment dealt out by the earlier gunships was enough to curb further enemy aggressiveness. 184/

Probably no other mission showed so clearly the capabilities and limitations of the Combat Rendezvous system. By using the system, Air Force gunships were able to provide continuous air support from 2215 until 0630. During this period, cloud cover had rendered all other sensors unusable. Each expending gunship was able to acquire the friendly position and commence firing within 10 minutes of arrival on station. Had it not been for this capability, the friendly forces almost certainly would have been overrun. As it was, Zulu Charlie's team was evacuated by helicopter at 0630 with NO casualties. This mission also highlighted the problem of short battery life and a-sence of spare batteries.

As a result, the 101st Airborne Division decided to insure that all of its beacons (7 SST-125s) were in working condition in the event of a similar situation. On 28 December, they formally requested 7AF to conduct routine airborne checks of these beacons. 185/ Seventh Air Force would

have honored this request, but subsequent events in northern Laos required every available gunship and beacon.^{186/}

THE DEFENSE OF LONG TIENG

On 19 December 1971, the North Vietnamese Army (NVA) launched an all out attack on friendly positions on the Plain of Jars (PDJ). Unseasonably bad weather hampered air support as the enemy offensive rolled remorselessly toward Long Tieng. Less than a week later the NVA launched a second attack in southern Laos which swept all friendly forces off the Bolovens Plateau and threatened Pakse. In response to an urgent appeal from 7/13AF, 7AF decided to employ four AC-119s and two AC-130s in conjunction with TEMIG and X-band beacons to overcome the weather problem.^{187/} To implement this plan, 7AF directed a reinstallation of APQ-133s in the AC-119s. The 16 SOS was also directed to insure that all of its aircraft were equipped for both Pave Mace and Combat Rendezvous missions. Both gunships squadrons were directed to place one aircraft on alert for a daytime mission; the ABCCC would divert normally fragged night missions as necessary. 7/13AF was directed to coordinate the entire operation. They were to distribute and account for all beacons, monitor the call signs, frequency, locations, and status of all beacons; and maintain a reserve of operational beacons for unexpected emergencies.^{188/} CAS already had 10 TEMIG I beacons and 200 batteries on hand.^{189/} These units were immediately distributed to the various FAGs along with a cursory briefing on their employment.

Meanwhile, 7AF was rounding up all X-band beacons for shipment to 7/13AF. When General Slay promised beacon support for Barrel Roll, he had been thinking in terms of the UPN-34 which had been used during the Krek/

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Tay Ninh operation.^{190/} However, all of these units were in the hands of the Army which was now as reluctant to give them up as they had earlier been unwilling to use them.^{191/} Nevertheless, 7AF was able to locate a number of SST-119s and 125s which had been turned over to the 101st Airborne Division following the Combat Rendezvous testing in June and July. These units were shipped to Udorn where they were found to be in marginal operating condition due to rough handling and lack of maintenance. Three usable SST-119s were eventually returned to the 101st while a fourth unit was turned over to CAS.^{192/} All remaining units were inoperable and were shipped to Det 6, ASD for disposal.^{193/} 7/13AF recommended that the remaining SST-119 be used until it failed, after which all beacon support would be provided by TEMIG beacons. The rationale for this recommendation was primarily weight--approximately one pound for the TEMIG beacon as compared with 20 pounds for the SST-119/125 units. Another consideration was the simplicity, ease of operation, and greater overall reliability of the Pave Mace system.^{194/}

However, the 7AF plan for the defense of Long Tieng placed its principal reliance for gunship support on the AC-119K, which was equipped to work only with the X-band beacons. Since it was now apparent that sufficient numbers of beacons could not be obtained in theater, 7/13AF was directed to order PPN-17s which had been selected by the Air Force following the PACAF conference and which were available through normal USAF supply channels.^{195/} However, OPLAN 796 specified that 7AF would acquire all X-band beacons and 7/13AF had neither the authority nor the

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money to purchase them. When these problems were pointed out to General Slay, he took prompt and decisive action. On 8 January, 7AF ordered six units and later requested an additional 10 beacons. Accountability for the beacons would remain with 7AF although actual deployment would be handled by 7/13AF. ^{196/}

The first of these beacons arrived at Udorn on 14 January 1972 but was not immediately useable: the coded pulse on the PPN-17 was not fully compatible with the APQ-133 and APQ-150 radars. ^{197/} This caused an additional delay of several weeks while the units were modified. ^{198/} Another problem was the absence of spare batteries for the transponders. These batteries were ordered on 18 January and when the supply depot at Tinker AFB questioned the validity of the requirement, 7AF replied with a sharply worded message:

We are cognizant of what constitutes a spare power supply and what constitutes spare monoblocks. As a matter of further explanation, several individuals may be deployed into different remote locations with one beacon each. These individuals may move numerous times and may not return to a base camp or staging area for several days. Access to any work area, tools, electric power, fixed DC power, would not be available and operations at night in jungle is anticipated. Troops in contact (TIC) operations with gunship support would preclude normal operation of replacing the discharged batteries. It is emphasized that this beacon is being used in field type operations and the operator only carries a weapon, food, the beacon, and spare power supplies for field deployment. We will also maintain a quantity of spare fully charged monoblocks at the main operating base for immediate replacement when the discharged spare power supplies can be funneled back from the deployed operation. It was

deemed more economical to requisition spare power supplies rather than complete beacon units for the deployment pick-up. Please be advised that this is an urgent immediate operational requirement. Request every effort to provide thirty spare power supplies from any source: either the contractor, if available, or from complete units presently in your depot assets. Please advise soonest. 199/

This message achieved the desired results. As these supply problems were worked out, the PPN-17s reached the field in February 1972. ^{200/}

Although excellent in many respects--light weight, powerful, easy to operate--it was found to be too delicate for the rough handling received under combat conditions. The antenna was easily knocked off, connections were jarred loose, and the set was subject to corrosion. In either of these situations, the unit was rendered inoperable. As a result, CAS eventually returned most of the units to 7AF and replaced them with the HLR-2, which it had been able to obtain through its own sources. Although inferior to the PPN-17 in some respects, it was a sturdy unit which was able to survive in the field. These units were supplemented by other X-band beacons which CAS already had or was able to acquire. ^{201/}

In contrast to the X-band, the TEMIG program encountered only minor problems. Due to the critical need for the beacons in the field, there was no time to conduct a proper training program. Instead, CAS officers took the units into the field to provide on-the-job training (OJT) for the FAGs. Unfortunately, all they could do was show the FAG the basic operating procedures. Since gunships were not yet operating in the day-time, there was no way to provide a live demonstration or permit actual practice. At night, the CAS officers were required to return to Vientiane

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leaving the FAG, oftentimes a teenager, to face the night and the enemy with a little gadget which he really didn't understand. Usually the FAGs first opportunity to use the beacon was when his position was actually under attack, at which time the safest place to be was in a bunker or building, either of which effectively blocked the beacon signal. ^{202/} Both 7/13AF and CAS worked to overcome this problem but it took time and experience to develop the confidence and ability to use the beacons properly. CAS did operate a six day training course for new FAGs at Udorn where the Pave Mace/ Combat Rendezvous systems were explained to the FAGs. However, the urgent need for every beacon in the field meant that only inoperative units were available for examination, let alone for practice. ^{203/}

The second problem was one of supply. Originally it had been believed that CAS would be able to obtain sufficient replacement units through their own supply channels. However, this was not the case and the Air Force made an emergency requisition. ^{204/} Twenty TEMIG Is and 15 TEMIG IIIs were shipped to CAS by 15 January while another five units of each type were sent to the 8TFW for use in checking out their Black Crow equipment. ^{205/} Thereafter CAS was able to satisfy its requirements through its own channels.

The first Pave Mace mission in support of Long Tieng was flown on 1 January 1972, but the aircrew was unable to contact any of the FAGs. Following several nights of unsuccessful attempts were made to use the beacons. ^{206/} The first successful Pave Mace mission was flown on January 5th. This one mission, however, made up for the earlier frustrations. In this instance, a friendly position was under attack by artillery from four different positions. A broken deck of clouds partially obscured the

target area making VFR operation impossible. However, the gunship quickly acquired the beacon signal and established voice contact with the FAG. The targets were approximately 900 meters from the FAG's position. The Spectre expended a total of 275 rounds of 40mm fire, completely silencing all four positions and causing two secondary explosions. The gunship remained on station, but the FAG reported his position secure and there was no more enemy activity. 207/

Thereafter the beacons were used frequently and to good effect. As they gained experience and confidence, both aircrews and ground personnel came to regard the system as highly effective, accurate, and reliable. During January, 24 successful missions were flown. Of these, 12 actually expended using the Pave Mace system at ranges varying from 100 to 1000 meters and in weather which was predominantly overcast. 208/ Seven of the other missions used the TEMIG beacon to locate the friendly position but were then able to fire visually or use their other sensors. The remaining five missions checked beacon operation only. In general, beacon reception was excellent with an average acquisition distance of 2.5 NM. 209/

BDA results from these missions were sparse due to weather and foliage, so no precise evaluation of their effectiveness was possible. However, FAG reports generally indicated either that the firing was very accurate or that the enemy had been repulsed. 210/ A typical report was issued by CAS after two AC-130s had provided support for friendly forces on the Bolovens Plateau. 211/

[REDACTED]

If not for Spectre 19 and Spectre 01 believe BG 404 would not have been able to hold. BG 404 and GM 42 both used TEMIG units to direct Spectre fire. Low clouds over op area prevented RLAF Spooky support and if not for TEMIG units there would have been no gunship support.

This particular mission also pointed up one of the continuing problems encountered in a fluid tactical situation -- that of beacons not being where they were reported to be. The CAS mission report described the situation and the action taken to correct it: ^{212/}

There was some confusion in which beacon was where during the night but this was straightened out and Pakse unit further coordinated with Spectre Ops Officer at Ubon on morning of 8 Jan. Do not anticipate any further problem between Spectre and TEMIG locations. TEMIG locations are specified in daily SITREP and any changes will be reported in separate ops cable.

Unfortunately these reports were often delayed several days in getting from the field units to a rear area where they could be sent to the USAF units concerned. In one instance, a FAG changed his position four times in eight hours due to the tactical situation. ^{213/} This made it virtually impossible to continuously update information on his position. The problem continued intermittently but it was only a minor inconvenience which the gunship crews learned to live with.

Several other missions during this same campaign are instructive in that they reveal particular problems as well as capabilities associated with Pave Mace/Combat Rendezvous. On 6 February 1972, an AC-130 supported

[REDACTED]

a FAG in the Long Tieng sector using the Pave Mace system. During the three hour mission, the gunship fired at a variety of targets, some of which were within 75 meters of the friendly position, in weather that was undercast. Although it was obvious that the FAG was pleased with the results -- frequently exclaiming: "Great! Shoot many, many time! Very good work!" -- there were several problems which the aircrew had to overcome. 214/

The first of these was a combination of the language barrier and inadequate training of the beacon operator. The targets consisted of personnel, guns, and a variety of vehicles, but the FAG simply classified everything as "trucks" and used that designator on his TEMIG I. This situation necessitated considerable voice contact in order to insure that the proper ordnance was used on the various targets.

The second problem was more serious in that it involved ROE. On several occasions, the FAG called for the Spectre to fire on targets that were too close to a village. As a result, considerable time was lost while this issue was being resolved. Throughout the mission, oral communications difficulties, the FAG's questionable ability to properly operate his beacon, and the questions of ROE were handicaps which the aircrew, fortunately, were able to overcome. 215/ However, the mission did point up the fact that although the TEMIG I was designed to bridge the language barrier, there was a clear advantage to having voice contact with an English speaking operator thoroughly trained in both the use of his beacon and in the ROE.

The value of Combat Rendezvous even under good weather conditions was illustrated near Pakse on the evening of 7 March. An AC-130,

[REDACTED]

Spectre 08, was diverted by ABCCC from an armed reconnaissance mission to support a TIC. Although the weather was VFR, the gunship was unable to locate the target area due to a malfunction in both his LORAN and TACAN equipment. Fortunately, the FAG possessed, and knew how to use, an X-band beacon whose signal was quickly acquired by the gunship's APN-59 navigation radar. Using the APN-59, the navigator was able to vector the gunship into a position where the beacon could be picked up by the APQ-150. At the time, the friendly position was receiving small arms, mortar, and rocket fire. After establishing voice contact with the FAG, the gunship was able to confirm his directions using the IR sensor and held the enemy at bay until all ammunition had been expended. Spectre 08 was then replaced by Spectre 16 which also acquired the FAG's beacon and continued to provide suppressive fire in all quadrants from 250 to 700 meters. Both Spectres employed the offset firing technique although they were able to confirm both the friendly and enemy positions using their other sensors and the FAG confirmed that all ordnance was on target. ^{216/} In this case, the FAG knew how to use his equipment, was well organized, and gave precise direction -- all factors which contributed to a successful mission.

On another mission in the same vicinity, an AC-130 acquired the X-band beacon and slaved his IR and TV systems to it. Shortly thereafter, the beacon signal died. However, the gunship was able to maintain acquisition using its other sensors thus demonstrating how a variety of sensors can be used to complement one another. ^{217/}

By late January, the enemy drive in Laos was losing momentum and CAS estimated that a total of 20 TEMIG and 12 X-band beacons continually deployed in the field would be sufficient to contain any renewed enemy threat.^{218/} As the action in Laos continued to decline, supply gradually began to catch up with demand and by March adequate numbers of beacons were on hand to meet CAS requirements. Meanwhile gunships continued to provide support using the beacon offset technique until 1 April when virtually every aircraft in theater was diverted to RVN to stop an all out NVA invasion.

THE NVA INVASION OF RVN*

As operations in Laos were slowed by the onset of the southwest monsoon, the scene of action shifted back to Vietnam where there was increasing evidence that North Vietnam was preparing for a major offensive against the RVN. Following the Krek/Tay Ninh operation, the Army began to take a positive attitude toward the Pave Mace/Combat Rendezvous program. Some units still had X-band beacons from the earlier programs, and as 7AF began to receive adequate supplies of the PPN-17 these units were deployed to various outposts in northern and central South Vietnam. By 21 February, there were five PPN-17s in MR I and six in MR II in addition to an unknown number of older beacons.^{219/}

*As this report was being prepared, Project CHECO was preparing a series of reports concerning the Air Force response to the NVA invasion.

[REDACTED]

Since these beacons were used only for TIC under IFR conditions, it was often days or weeks before they were actually employed, and they were always subject to rough handling. Without some means of field-checking the beacons, there was no way the ground commander could be assured that his beacon would work when needed. To overcome this problem, General Slay directed that gunships perform regular checks of all beacons in their operating areas.^{220/} The check was to consist of acquisition, lock on, and tracking of the beacon. To save ammunition for the gunships' primary mission, practice firing was not conducted. While this procedure helped to insure that all beacons were operating properly and that inoperative units were being replaced, it did not afford either the air or ground forces an opportunity to develop experience and confidence in actual air/ground control procedures and fire adjustment. At first these checks were performed nightly, but when it developed that this was consuming too much of the gunships' orbit time, it was changed to every three days and later to every five days. During the month of March, gunships performed 28 beacon checks which revealed 13 inoperative beacons.^{221/} It was often several days before ground units were able to replace the inoperative beacons, but at least they knew what their status was. This particular mission was extremely unappealing to the aggressive gunship crews, who preferred to spend their time destroying trucks or supporting TIC.^{222/} However, until a means of field checking was developed, it was necessary.

On six occasions during March, the gunships were actually able to employ the system. All of these missions involved TIC and were flown under actual IFR conditions where the Combat Rendezvous was the only

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useable system. Three of the missions reported RNO due to weather, but the other three reported a total of 12 KBA, one armored vehicle destroyed, numerous small secondary explosions, 15 medium secondary explosions, and four large fires. But most important, none of the six outposts was ^{223/} overrun.

This experience, limited though it was, stood both the air and ground forces in good stead the following month when Combat Rendezvous faced its severest test and received its most complete vindication. On 30 March 1972, the NVA launched a well coordinated all out attack on three widely separated fronts. The USAF responded by diverting virtually its entire force in SEA to support the South Vietnamese. AC-130s were diverted from their truck killing campaign in Laos to support ARVN forces throughout the Republic. Due to their shorter range, the AC-119s at Da Nang were limited to the northern half of the country. To fill the gap in the south, five AC-119s were moved from NKP to Bien Hoa to support the critical An Loc ^{224/} sector.

As with the Krek/Tay Ninh operation, the enemy attack was timed to take advantage of a period of bad weather which limited USAF close air support. Again, beacon offset firing did much to strip the enemy of this protective shield. That the gunships were not even more effective was due to the fact that there were simply not enough beacons in RVN to cover all of the fronts. To fill this gap, 7AF requested CAS to recall all of the TEMIG beacons from Laos and turn them over to 7AF for deployment in RVN. ^{225/}

Subsequently 20 TEMIGs were delivered and distributed to the field along with a number of "pipes," a version of the TEMIG II. ^{226/} Additionally, 7AF received a shipment of 38 SST-125s 20 UPN-34s and an unspecified number of improved (12 watt) miniponders and PPN-17 beacons. ^{227/} As before, the large number of different types of beacons, the lack of interchangeable parts, problems of supply, spare batteries, rough handling, maintenance, and operator training were limiting factors on beacon employment. In addition, it was soon discovered that the Pave Mace system would be virtually unuseable in RVN due to excessive interference from troposcatter communications systems. ^{228/} The result was that most of the TEMIG beacons were withdrawn from the field and returned to 7AF. In spite of these limitations, 53 of the 384 gunship sorties flown during the first two months of the operation used Combat Rendezvous while 12 missions employed Pave Mace. ^{229/} In general the AC-130s were more successful than the AC-119s due to better overall aircraft performance and to the APQ-150 radar.

Since the gunship missions were interspersed with other strike aircraft, complete data on mission results and BDA was not available. However, a mission on 3 June near An Loc is representative of the missions flown during this period. On that night, a Spectre gunship was supporting "Citizen 65R" in cloudy weather. Throughout the mission, the gunship fired at a variety of targets ranging from 740 to 900 meters. According to the mission report: ^{230/}

Citizen 65R said we were the first Spectre to use the X-band beacon this successfully, no other sensor could see the target, we fired offset off the APQ-150 all night without using any other sensors. The ground controller said we were hitting "right on" all the time. Excellent Combat Rendezvous mission!

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Any number of other missions could be related but they would simply be redundant. The pattern was well established: clouds obscuring the target area, no other system capable of working in close to the friendlies, outstanding results using beacon offset firing.

On the other hand, there were numerous instances where gunships were unable to use the beacons, with the result that friendly positions were overrun. In at least one instance, the friendly position was within the NVA Surface-to-air Missile (SAM) envelope and the gunships were unable to operate in the area.^{231/} In other instances, enemy AAA was so heavy that the gunships were either driven off or were so busy dodging enemy AAA that they were unable to operate effectively. In particular, the SA-7 "Strella" -- which was responsible for downing at least one gunship -- was feared by the aircrews. Although flares were partially effective in decoying the Strella, it remained a potent threat to all gunship operations.^{232/} This problem was really one of gunship survivability regardless of the sensor system being employed.

A similar problem was that of air traffic control. With the high density of aircraft -- gunships, fighters, and bombers -- each with different operating parameters, all working the same target area at the same time, it was not uncommon for a controller to have as many as 40 "blips" on his scope when he could only effectively control 14 or 15 at one time. At times aircraft actually flew through bombs being dropped by other aircraft or through the gunships' firing pattern.^{233/} Miraculously there were no midair collisions and no aircraft were lost to other friendly aircraft.

[REDACTED]

Inevitably, however, this situation led to a certain amount of confusion and loss of efficiency. This problem was not related to the Combat Rendezvous/Pave Mace system, per se, but affected all systems equally.

A more specific problem arose when the friendly position did not possess an operating beacon or did not know how to use it properly. One such incident occurred during the early stages of the battle for An Loc. As usual the weather was a solid undercast and the ground commander, "Tunnel 10," was asked if he had an X-band beacon. According to the mission report: ^{234/}

Tunnel 10A first replied that he had no such apparatus. However, within a few minutes he came back with a report that he had located a crate in his shelter that had a bunch of electronics gear in it. The serial number he read to the crew was recognized by the BC as that of the X-band beacon. Tunnel 10A then asked for a few minutes to "read the instructions and set this baby up." About 15 minutes later he reported that he had assembled it and "a lot of lights were lit up." The BC then attempted to track the beacon on his APQ-150 but with no luck. The cause was soon discovered. Tunnel 10A called up on the radio that he had looked a little closer at some of the lights and one of them says that the battery is too weak to run the beacon." That ended Spectre's first attempt at off-set beacon firing at An Loc.

A similar -- but more tragic -- incident occurred in MR I when a small fire support base near the Demilitarized Zone (DMZ) came under heavy attack from the NVA. A layer of clouds 500 to 1000' above the ground completely obscured the position, but the defenders had an X-band beacon. When the gunship arrived overhead, the crew requested the American advisor to turn on his beacon. Braving the rain of enemy fire, the American

reached the beacon which was located some distance from the command bunker and turned it on, only to find that it was inoperative. Whether from a weak battery, internal failure, or enemy artillery will never be known. 235/
In the words of one of the crew members on this mission:

We were quite a frustrated crew hovering directly over his position and unable to expend because there was no means of positively locating him. He was even willing to have us fire right on top of his position if we could just find him. FM homing wasn't precise enough--got us within a mile--and had it been FVR we could have seen him and gone right to work. That beacon had been our last hope and without it we were helpless. If that beacon had been working I am sure we could have saved that support base or at least prolonged the fight for another day or so. If they had just had an operating beacon.

The following day, the fire support base was overrun. There was no report of any survivors. 236/

Even in good weather, the value of Pave Mace/Combat Rendezvous was dramatically demonstrated by a mission in support of "Hedgehog Charlie." 237/
In this case the crew reported:

Spectre 14 did not expend for entire TOT because could not positively identify friendlies. Whiskey (ARVN) had only a flashlight to mark his position. Hedgehog "C" tried firing 105mm flares at enemy position to mark. Neither method was good because of numerous flares, lights, and fires on ground. It's next to impossible to help under these circumstances and when friendlies are near no easily recognizable land marks. Ground forces need better markers such as X-band beacons.

This lack of familiarity with beacons on the part of the ground forces and the failure to include them in the Vietnamization program came

as something of a surprise to many of the gunship crews who had been using the beacons regularly in Laos. As the 16 SOS noted: ^{238/}

The ignominious lack of beacons in the hands of our own personnel had to be a grave oversight by friendly air and ground personnel.

However, it should be remembered that the Army had only lately become interested in beacons and they were now paying the price.

To correct this situation, the 8TFW explained to 7AF what was needed: ^{239/}

Whoever controls Spectre should (1) understand most effective use is achieved when the gunship can hunt and expend throughout the entire TOT; (2) brief the gunship on mission objectives and location of friendlies and enemy while gunship is inbound to the target, using secure voice as necessary; (3) avoid shuttling the gunship back and forth among FACs and FAGs unless an actual emergency arises; (4) take advantage of the AC-130's unique detection capability and pinpoint accuracy and avoid area shooting wherever possible. Also, U.S. ground forces should understand that if the weather deteriorates the gunship will require X-band or TEMIG beacons for accurate close support.

In response to this message, briefing teams from the 16 SOS and ASD were dispatched to various units throughout Vietnam to explain the beacon offset system to the ground forces. As a result of these briefings, there was more frequent use of the beacons in the later stages of the campaign. ^{240/}

By 1 July, the cutoff date for this report, the enemy offensive had been halted and friendly ground forces were beginning to recapture some of

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only

the lost ground. Exactly what role Pave Mace/Combat Rendezvous would play in these and future operations was unclear. Whether the beacons would once again be relegated to the storage bins of a supply depot and the hard earned experience allowed to slip away was clearly a decision which had to be made by both the Army and the Air Force. In making that decision, it might be well to keep in mind the admonition: "If they only had an operating beacon!"

CHAPTER IV

CONCLUSION

The development of Pave Mace/Combat Rendezvous represents far more than just another gunship sensor. Rather, it is a complete air/ground system which constitutes a revolutionary breakthrough in the all-weather employment of air power for direct support of ground forces. As such, it adds an entirely new dimension to USAF fixed wing gunship capability. For the first time, ground forces are able to accurately direct aerial fire within 30 meters of their own positions with complete safety. In fact Pave Mace/Combat Rendezvous is the only Air Force close air support system to date which has never produced a short round incident. The safety standards imposed by the USAF are such that if any element of the system is not working properly it is automatically a "no fire" situation. And when the system is working -- it is unmatched in accuracy.

The Pave Mace/Combat Rendezvous system has also proven to be the quickest and most positive way to acquire both friendly and enemy positions in either good or bad weather! Without the use of beacons, it was not uncommon for gunships to spend as much as 30 minutes acquiring the target before they could commence firing.^{241/} Even then, aircraft maneuvers often cause the gunship to "lose" the target, thus necessitating reacquisition. On the other hand, with an operating beacon, target acquisition was often achieved during the first orbit and in no case were more than 10 minutes required.^{242/} Moreover, the beacons permit continuous tracking of both friendly and enemy positions thus permitting a more continuous fire without going through the reacquisition process.^{243/}

Although the Pave Mace/Combat Rendezvous system has so far been used primarily in the defense of fixed sites, its offensive applications in good or bad weather should be equally apparent. As a 16 SOS report ^{244/} noted:

In the hands of US forces, properly maintained and wisely utilized, unlimited potential is afforded thru gunship support. If the system were made available to long range patrols, ambush or road watch teams, fire support bases, convoys (water and land) or advancing infantry/armor units - gunships could deliver a devastating barrage of fire power where needed. Even more interesting, with Pave Aegis program is airborne artillery support. Durability of beacon should be enhanced in the field. Proper education of user is of paramount importance.

It should also be noted that in the hands of friendly foreign forces the system was no less effective as long as the caveats of proper maintenance and wise utilization were observed. The potential use of beacons in a SAR role has already been mentioned and its application to other aircraft has been considered. One such application is the Combat Sierra program in which an air dropped beacon is used to provide offset information for B-52 strikes. At the present time, data on this program is incomplete but preliminary results indicate that a 200 meter CEP can be expected. ^{245/} The hardware is already available and its effectiveness has been demonstrated. All that is required is to develop the necessary procedures.

From the beginning, the program encountered technical and human obstacles which very nearly scuttled the entire project. Not the least of these problems was the unwillingness of the Army to support the program.

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Since Pave Mace/Combat Rendezvous was an air/ground system, the active participation of the ground forces was absolutely essential. By withholding that participation, the Army almost killed a system which ultimately saved Army lives. Of course, not all elements within the Army were opposed to the Pave Mace/Combat Rendezvous system. A number of Special Forces and regular Army field commanders were enthusiastic about the program and lent it what support they could. In general, the Army along the Vietnamese border was far more receptive to the idea than the Army in Saigon or on the banks of the Potomac. Initially, however, it was MACSOG and CAS which provided the necessary ground user for the system. In particular the role of CAS was crucial in keeping the system alive when even the Air Force was about to give up. Without their support, and in some cases prodding, the whole project might well have been abandoned -- or indeed might never have gotten started.

Another problem was the annual turnover in personnel which deprived the program of much needed continuity and which resulted in numerous delays as old lessons had to be relearned. This problem was complicated by the apparent lack of any systematic procedure for the rapid introduction, combat evaluation, and operational employment of new weapons systems. The process by which the system was developed and deployed was often unconventional, outside of "normal" channels, and found various USAF agencies working at cross purposes. It was not until the PACAF Conference of 20-22 July 71 that the project was put on a systematic basis and even then it required the personal intervention of General Stay to get the system into full operational employment.

[REDACTED]

Even with the system fully operational, a number of problems continued, but most were overcome by improved equipment design and better indoctrination. The most common and most serious problem was the high failure rate of the ground beacons, caused by rough handling and lack of preventive maintenance. Since it was unrealistic to expect laboratory care of an instrument under field conditions, the solution appeared to be an improved design which was not only simple to operate but was shock and corrosion resistant. The second most common cause of beacon failure was weak batteries and insufficient spares. As with the beacons themselves, batteries were often subject to physical abuse in field conditions which shortened their normal operating life. Again, improved design along with an improved supply system would go far to relieve this problem. Associated with these two problems was the absence of a built-in test circuit on most of the beacons. In some instances, one X-band beacon could be used to check another, but in a field situation this was usually impractical. The only way most ground users could tell if their equipment was operating was to have a gunship check their beacons. This was a time consuming process at best, and detracted from the gunship's primary mission. As a compromise measure, 7AF attempted to check every beacon on a five day cycle, but in practice this was never achieved on a systematic basis due to primary mission requirements. When everything was working, the check could be completed in less than 10 minutes, but if the set was not working as much as 30 minutes mission time could be lost while batteries were changed, or the set was being adjusted and the system rechecked. This entire problem could have been eliminated by incorporating

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a simple "go-no-go" meter into the beacon chassis.

A related problem was the proliferation of various types of ground beacons. As of this writing, there were at least four types of TEMIG and six types of X-band beacons. In most cases, each of these types required a different type of battery. Nor were other components of the various models readily interchangeable. This problem could have been overcome by the adoption of a single model for each system -- or perhaps a single unit which combined the features of both systems. Such a unit would have to have been both compact and powerful, about the size and weight of the TEMIG I or miniponder but with a power output of at least 30-50 watts. The automatic target designation, range and bearing of the TEMIG I would have been a "nice to have" feature, but in view of the requirement for voice contact, would not have been a necessity. The caveat of simplicity, shock and mildew resistance would also need to be observed. The standard battery should be a small, powerful, interchangeable and rechargeable unit but the set should also be able to operate off any available power source. The X-band section should incorporate the shielding features of the PPN-17, which would permit operation of beacons within one mile of each other. Finally the redesigned beacon should have a built-in test circuit to check beacon operation.

A third problem area stemmed from the relatively small number of each type of beacon and the limited in-theater repair capability which required excessive delays while units were returned to the CONUS and replacement units distributed to the users. This problem was all the

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acute since there were at least three different supply agencies involved -- the Army, the USAF, and CAS -- each with its own system. The PACAF Conference of 20-22 July 1971 called for a "single manager" concept of beacon procurement and distribution and for a while it appeared that this was being done in the case of the X-band beacons -- though not for the TEMIG units. However, the PPN-17, acquired under this concept, was not acceptable to all ground users and the multiple acquisition system gradually returned. A return to the single manager approach, as called for in the PACAF Conference, and the design of an improved beacon -- or family of beacons with readily interchangeable parts and batteries -- still seemed to be a valid solution to supply and maintenance problems.

An operational problem which complicated, and was complicated by, the supply problem was the low use rate of the beacons in the field. Although the Pave Mace/Combat Rendezvous system had been designed primarily as an adverse weather system, it should be kept in mind that it was an all-weather system, no less effective in good weather than in bad. Yet there seemed to be a reluctance to use the system except in bad weather. This infrequent use tended to erode confidence, allowed procedures to become rusty, and led to a neglect of the equipment. As Colonel Denning Perdew, ^{246/} Assistant Deputy Commander, 7/13AF pointed out:

What we need to do is use the beacon in every TIC situation, regardless of the weather. In fact, whenever a gunship is fragged for the support of ground forces it should use the beacon even if there is no TIC. And I don't mean just check the beacons. I mean actually fire. That way the FAGs can get practice adjusting fire and develop confidence in their own and the gunship's ability to deliver accurate fire. It might also serve to discourage

anyone who might be contemplating an attack.

As if to emphasize Col Perdew's statement, gunship crews reported that the greatest difficulty encountered was the tendency of ground forces to request fire support beyond the effective range of the system. Although the improved TEMIG I could automatically designate targets up to 2,000 meters and the improved fire control system of the AC-130E could accept ranges up to 10,000 meters, angular errors at these extreme ranges caused an unacceptable loss of accuracy. For this reason, the maximum practical range of the system was determined to be 1500 meters.^{247/} The only way that the problem of improper use of the system could be overcome was through better training, indoctrination, and -- most important of all -- through extensive use of the system in the field under both good and bad weather conditions. Associated with the problem of infrequent and improper use of the beacon system was the reluctance on the part of some ground commanders to use the system even when a TIC situation does exist. Since gunships were not always available, while organic fire (rifles, machine guns, grenades, etc.) was, the ground commander naturally came to rely on his own resources. As a situation became critical, there was a tendency to rely on that which he knew best -- his own organic firepower -- even though a gunship might be available and was by far the most effective support weapon available to the ground commander. During the defense of Long Tieng as well as during the NVA invasion of RVN, there were numerous occasions where gunships and beacons were available but were not used because of a lack of familiarity with and confidence in the system.^{248/}

The PACAF Conference suggested that this problem might be overcome in

part by giving the beacons to the ALO, who would be the most familiar with air support operations, and who would be in a position to advise and encourage ground commanders in the proper employment of the system. This suggestion was not implemented at the time since American combat units were rapidly withdrawing from the combat role. However, in any future operation involving gunship support of U.S. ground forces, it would still appear to be a valid suggestion. In the case of gunship support to indigenous forces, especially where U.S. advisors are not present, the Laotian FAG program would seem to serve as a model of what can be done. Except in the case of the TEMIG I, the language barrier would always present a problem but, as the FAG program has shown, not an insurmountable one. Due to the critical situation at Long Tieng, the FAG mortality rate, the need for replacements, and the shortage of beacons, training was not always as thorough as desired. In some cases, the FAGs were as frightened of the "devil in a box" as they were of the enemy. ^{249/} In other cases, their inexperience and lack of training led to improper use of the system such as requesting fire at excessive ranges, placing the unit inside a bunker or alongside of buildings, artillery pieces or PSP planking -- all of which degraded the signal. However, those FAGs who survived gradually gained the experience necessary to employ the system effectively. Following the defense of Long Tieng, however, both the beacons and the gunships operating in Laos were greatly reduced. Although this move was necessitated by the NVA invasion of RVN, it cost the Laotians valuable experience which would have to be made up again in the future. Thus, although the FAG program was perhaps not the ideal solution, it appeared to be the best program available and serious consideration should be given to a similar

[REDACTED]

program for the South Vietnamese, and perhaps other MAP countries as well.

Finally, in comparing the two systems, the important thing to keep in mind is that both systems worked. In Laos, the TEMIG beacons were generally more successful than the X-band beacons while in RVN the situation was reversed. Thus the two systems were complementary rather than competitive. The Pave Mace system had the advantage of using a sensor - the Black Crow - which had other uses, while the APQ-133/150 was used only with the X-band beacons. However, the desire to protect the Black Crow technology precluded this equipment being installed in MAP country gunships. Thus these countries were in effect limited to the Combat Rendezvous system. Although the X-band beacon provided a more stable signal, both signals were sufficiently stable to permit accurate firing. In fact the Pave Mace system actually appeared to be superior in overall tracking ability. A random sampling of mission reports for the first quarter of 1972 showed that the Pave Mace system was able to track on 14 of 14 occasions while the Combat Rendezvous system was able to track on six out of 14 occasions.^{250/} The principal culprit in the remaining eight cases was a weak or inoperable beacon.

In general, aircrews who were experienced with both systems seemed to prefer the TEMIG beacon. According to the 16 SOS:^{251/}

From aircrew standpoint, TEMIG I is an excellent beacon; reliable, accurate, and easy to use ... TEMIG/Black Crow combination affords rapid target acquisition and accurate fire power easily employed on enemy positions. Confusion and language barriers are overcome electronically through use of TEMIG I beacon ... TEMIG beacons do not have limitations of

having to be separated by at least 10 nautical miles to prevent mutual interference, as is the case with X-band beacons. TEMIG beacon is much lighter and more easily deployed in a tactical situation than X-band beacons.

CAS also preferred the TEMIG because of its size and weight and because they felt that it was more reliable under jungle canopy. In particular, CAS preferred the TEMIG I because of its automatic features which served as a check on voice instructions, and vice versa.^{252/} The TEMIG beacons also appeared to be less sensitive than the X-band beacons and less subject to malfunction under field use.

Many of the weaknesses of the X-band system had been or could be overcome by improved system design. For example, PPN-17s could be used within one mile of each other without causing interference. This was actually better than the TEMIGs which required 1 1/2 mile separation. Reliability and survivability appears to be more a function of specific unit design than inherent characteristics. Nor was miniaturization an impossible feat as shown by the miniponder which, however, suffered from inadequate power. Again this appeared to be more of an engineering problem than a systemic problem. The automatic feature of the TEMIG I was somewhat offset by the requirement for voice contact to confirm beacon information. It was for this very reason that the TEMIG II, III, and IV were developed.

In summary then, each system has its advantages and disadvantages; but both work. After many trials, in spite of opposition and indifference, the USAF possessed an in-being all-weather close air support capability

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whose accuracy was unmatched by any other system. Future applications of the system were limited only by the imagination.

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APPENDIX

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OPERATIONAL COMPARISON (ACQUISITION RANGE NAUTICAL MILES)

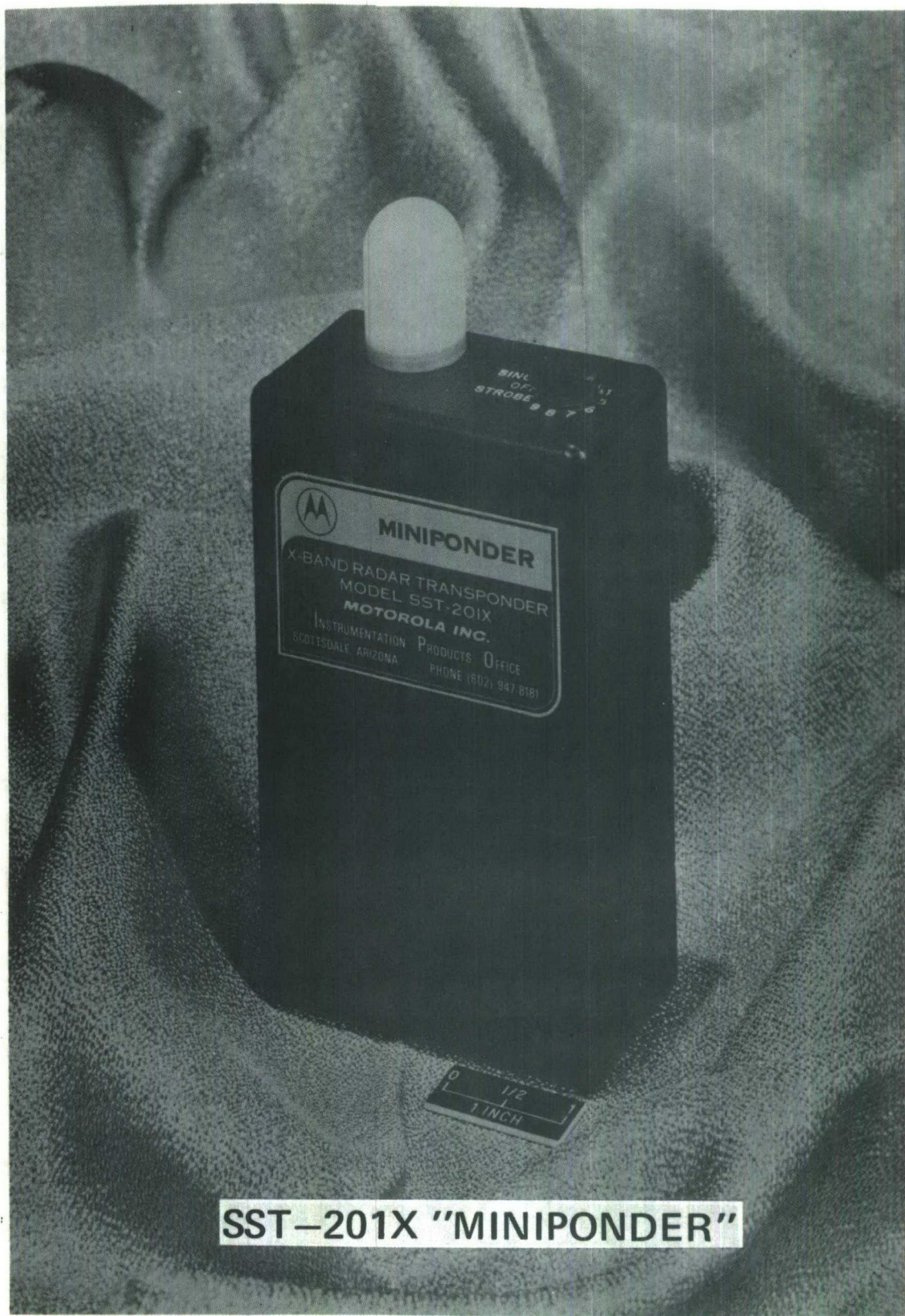
LINE OF SIGHT	SST-119X (TAFSEA BEACON AND AIR DELIV- ERABLE TRANS- PONDER)		SST-181X (AN/UPN-25 & AN/UPN-34)	
	SST-201X			
AN/APQ-133	TYPICAL	6.1	3.0	8.5**
	MINIMUM	1.21	1.7	8.5**
	TYPICAL	10.5**	7.9	10.5**
	MINIMUM	8.1	4.6	10.5**
*IN FOLIAGE				
AN/APQ-133	TYPICAL	0.61	0.3	6.8
	MINIMUM	0.12	0.2	1.2
AN/APQ-150	TYPICAL	1.5	0.8	10.5**
	MINIMUM	0.8	0.5	8.1

*NUMBERS COMPUTED BASED ON TRIPLE CANOPY FOLIAGE TYPICAL OF SAN JUAN, PUERTO RICQ RAIN FOREST

**RANGE LIMITED BY ACQUISITION RANGE OF RADAR

FIGURE 6

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SST-201X "MINIPONDER"

FIGURE 7

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LEADING PARTICULARS SST-201X MINIPONDER

RECEIVER-

- CRYSTAL VIDEO
- 8.5 TO 9.6 GHz
- SENSITIVITY -46 DBM TYPICAL, -43 DBM MINIMUM

TRANSMITTER-

- POWER OUTPUT - 5 WATTS TYPICAL, 3.3 WATTS MINIMUM
- 9.31 GHz (± 1 MHz TUNING)
- SINGLE & SELECTABLE TWO PULSE REPLY

POWER-

- DETACHABLE BATTERY PACK
- 120 HRS STANDBY OR 8 HRS TRANSMIT

PASSED MIL-STD-810B TESTING BY U.S. ARMY TEST AND
EVALUATION COMMAND.

FIGURE 8

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AN/UPN-25 TRANSPONDER SET

FIGURE 9

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UNCLASSIFIED

**LEADING PARTICULARS
AN/UPN-25 TRANSPONDER SET**

RECEIVER—

- SUPERHETERODYNE
- TUNABLE 8.8 TO 9.5 GHz
- SENSITIVITY -68 DBM TYPICAL, -65 DBM MINIMUM

TRANSMITTER—

- POWER OUTPUT - 300 WATTS MINIMUM
- TUNABLE 8.8 TO 9.5 GHz
- SINGLE & SELECTABLE TWO PULSE REPLY

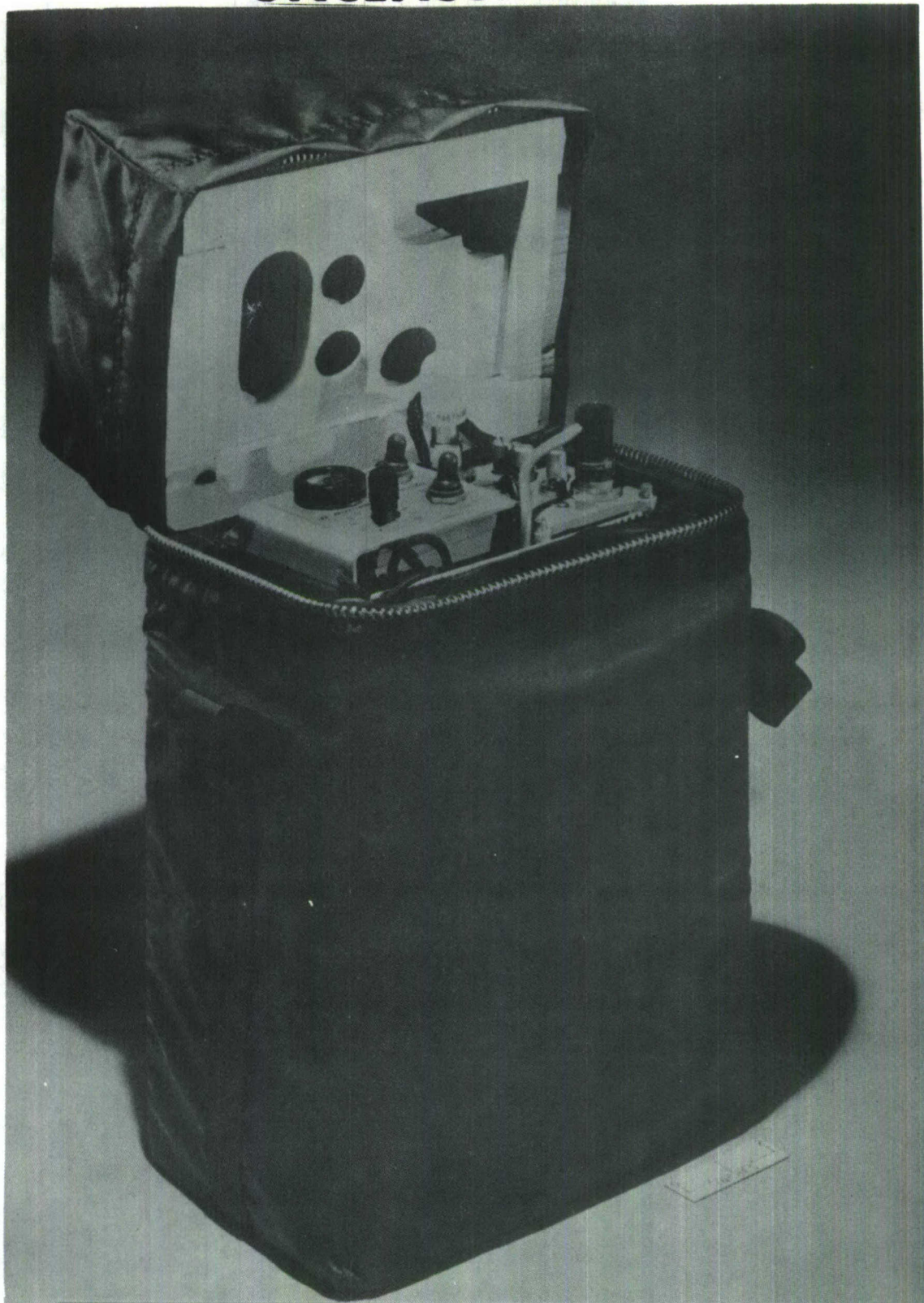
POWER—

- MAY BE USED WITH ANY 24 TO 30 VDC BATTERY.

FIGURE 10

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AN/UPN-34 GROUND LOCATOR BEACON

FIGURE 11

UNCLASSIFIED

UNCLASSIFIED

**LEADING PARTICULARS
AN/UPN-34 GROUND LOCATOR BEACON**

RECEIVER—

- SUPERHETERODYNE
- TUNABLE 8.8 TO 9.5 GHz
- SENSITIVITY -68 DBM TYPICAL, -65 DBM MINIMUM

TRANSMITTER—

- POWER OUTPUT - 300 WATTS MINIMUM
- TUNABLE 8.8 TO 9.5 GHz
- SINGLE & SELECTABLE TWO PULSE REPLY

POWER—

- REPLACEABLE BA-1509/PRC-64 (2 EA)
- 8 HRS STANDBY OR 4 HRS TRANSMIT

FIGURE 12

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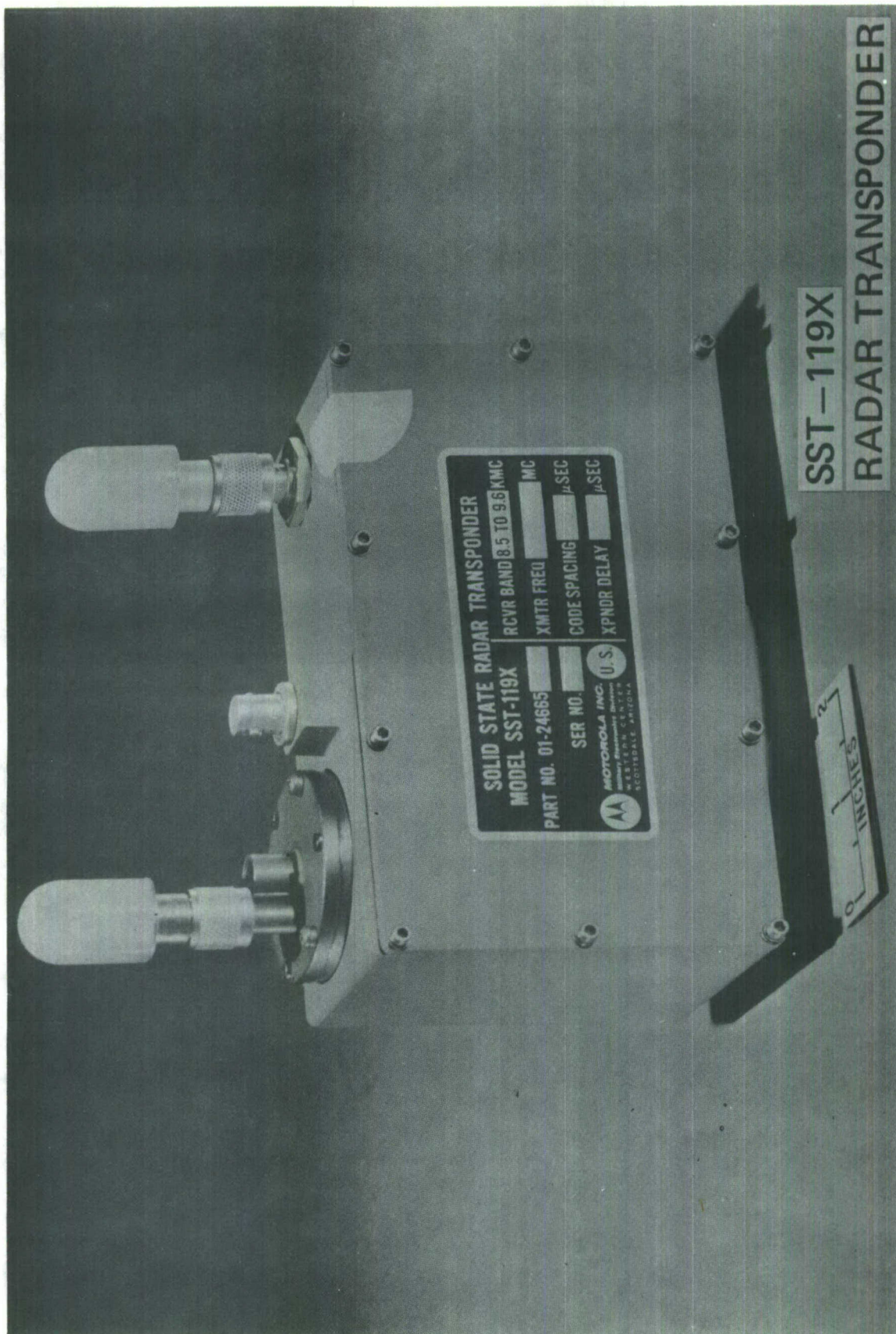


FIGURE 13

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LEADING PARTICULARS TAFSEA BEACON

RECEIVER—

- CRYSTAL VIDEO
- 8.5 TO 9.6 GHz
- SENSITIVITY -40 DBM TYPICAL, -35 DBM MINIMUM

TRANSMITTER—

- POWER OUTPUT -50 WATTS MINIMUM
- TUNABLE 9.275 TO 9.405 GHz
- SINGLE PULSE REPLY

POWER—

- RECHARGEABLE GEL/CELL BATTERIES
- 32 HRS STANDBY OR 16 HRS TRANSMIT

FIRGURE 14

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SST-125X
AIR DELIVERABLE
RADAR TRANSPONDER

FIGURE 15

UNCLASSIFIED

UNCLASSIFIED

**LEADING PARTICULARS
SST-125X RADAR TRANSPONDER**

RECEIVER—

- CRYSTAL VIDEO
- 8.5 TO 9.6 GHz
- SENSITIVITY -40 DBM TYPICAL, -35 DBM MINIMUM

TRANSMITTER—

- POWER OUTPUT - 50 WATTS MINIMUM
- TUNABLE 9.275 TO 9.405 GHz
- SINGLE PULSE REPLY

POWER—

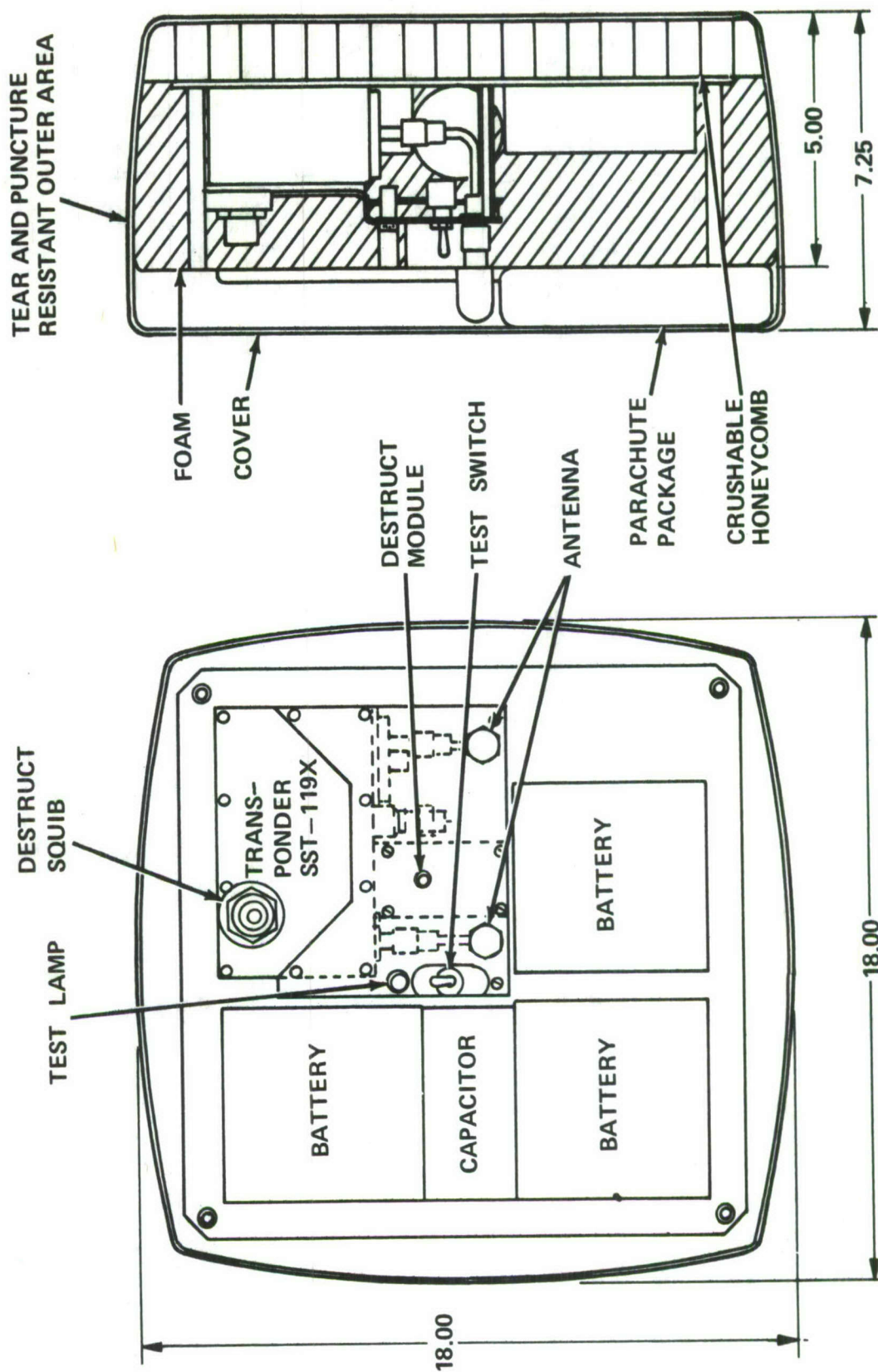
- INTEGRAL BA-1509/PRC-64 (3 EA)
- BETWEEN 2 AND 8 HRS OPERATION

SUCCESSFULLY COMPLETED USAF AIR DROP TESTS

FIGURE 16

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INTERNAL DETAILS OF AIR DELIVERABLE TRANSPONDER PACKAGE



COVER AND PARACHUTE NOT SHOWN

FIGURE 17

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UNCLASSIFIED

RADAR SET AN/APQ-133

CONTROL INDICATOR GROUP

RADAR SET GROUP

RADAR SET CONTROL
AND POWER SUPPLY GROUP

FIGURE 18

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UNCLASSIFIED

LEADING PARTICULARS AN/APQ-133

TRANSMITTER	
PEAK POWER	300 WATTS MIN
FREQUENCY	9375 MHz
PULSE REPETITION FREQUENCY	800 PPS
RECEIVER	
ACQUISITION SENSITIVITY	-50 DBM MIN
CENTER FREQUENCY	9310 MHz
BANDWIDTH	8 MHz
ANGLE TRACKER	
TYPE	CONICAL SCAN
ANTENNA - DISH	31.5 DB GAIN
SCAN	30 X 30 DEGREE SECTOR
GIMBAL DRIVE	HYDRAULIC
ACCURACY	4 MILS RMS (ESTIMATED)

FIGURE 19

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LEADING PARTICULARS (CONT)

AN/APOQ-133

Modes

1. MANUAL ACQUISITION
2. AUTOMATIC ACQUISITION

Display

AZIMUTH AND RANGE PRESENTATION ("B" SCOPE)
SELECTABLE RANGE PRESENTATION 0-4 NM, 0-8 NM
VISUAL DISPLAY OF RANGE TRACKER POSITION

Beacon Discrimination

DECODER; SINGLE AND TWO PULSE COMPATIBLE WITH MOTOROLA
BEACONS:

SST-119X

SST-125X

SST-201X

AN/UPN-25

AN/UPN-34

OTHERS IN SINGLE PULSE REPLY

FIGURE 19a

UNCLASSIFIED

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RADAR SET, AN/APO-150

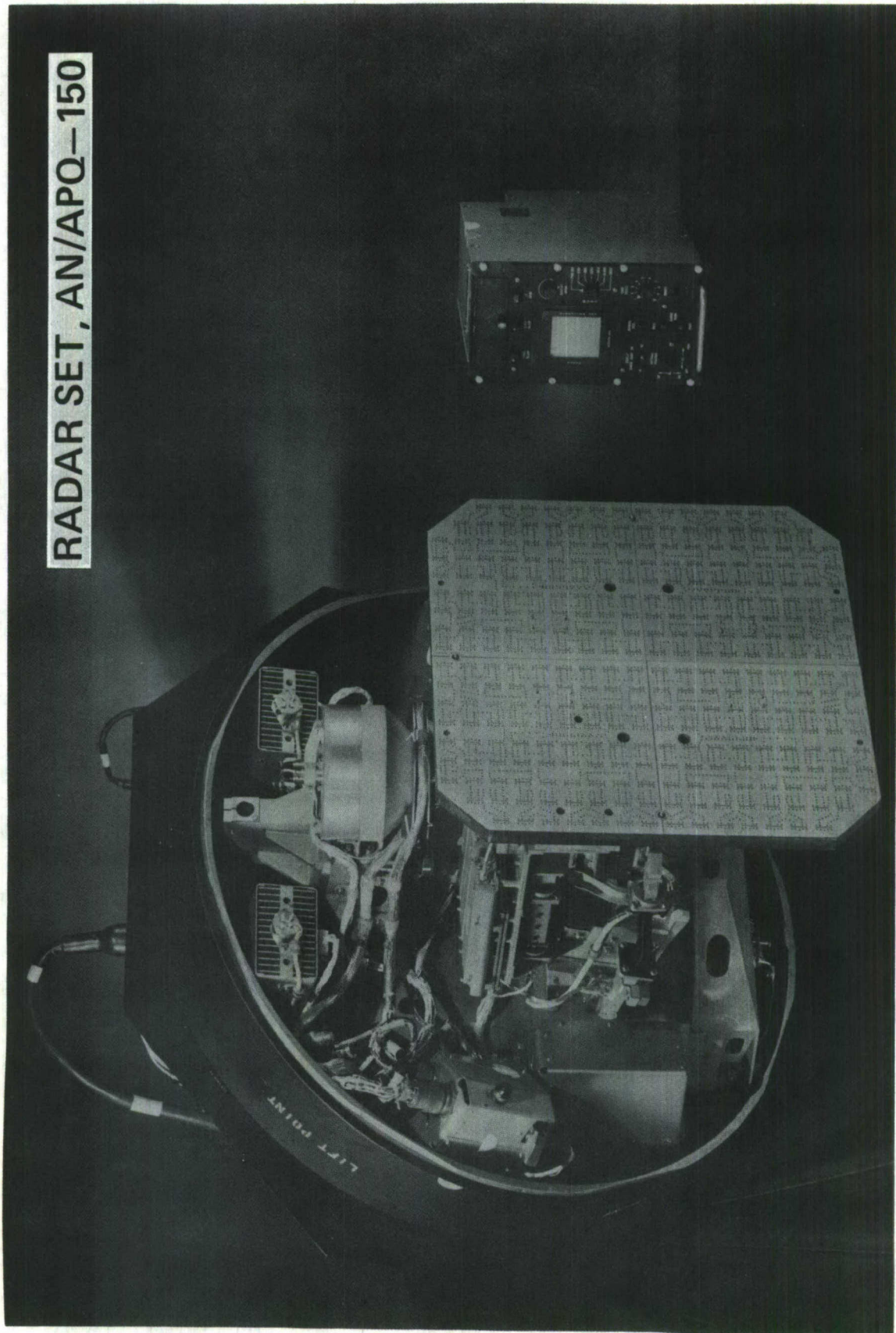


FIGURE 20

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UNCLASSIFIED
LEADING PARTICULARS
AN/APQ-150

TRANSMITTER	
PEAK POWER	5000 WATTS
FREQUENCY	9375 MHz
PULSE REPETITION FREQUENCY	800 PPS
RECEIVER	
ACQUISITION SENSITIVITY	-70 DBM MIN
CENTER FREQUENCY	9310 MHz
BANDWIDTH	16 MHz MIN
ANGLE TRACKER	
TYPE	MONOPULSE
ANTENNA	FLAT PLATE DISTRIBUTED ARRAY - 30 DB GAIN ELEVATION AND SPIRAL ELECTRIC
SCAN	2 MILS RMS
GIMBAL DRIVE	
ACCURACY	

FIGURE 21

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UNCLASSIFIED

LEADING PARTICULARS (CONT)

AN/APQ-150

MODES

1. MANUAL ACQUISITION
2. AUTOMATIC ACQUISITION
3. SLAVE
4. MICROWAVE TARGET DESIGNATOR (MTD)
5. BORESIGHT

DISPLAY

AZIMUTH AND RANGE PRESENTATION ("B" SCOPE)
SELECTABLE RANGE PRESENTATION 0-5 NM. 0-10 NM
VISUAL DISPLAY OF RANGE TRACKER POSITION

BEACON DISCRIMINATION

DECODER; SINGLE AND TWO PULSE CODE, COMPATIBLE WITH
BEACONS:

SST-119X
SST-125X
SST-201X
AN/UPN-25
AN/UPN-34

OTHERS IN SINGLE PULSE REPLY

FAULT ISOLATION CIRCUITRY

BUILT-IN-TEST EQUIPMENT (BITE)

FIGURE 21a

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OPERATION OF TAFSEA BEACON WITH STINGER AC-119K GUNSHIP

1. Select a location to place the beacon.

a. Keep it above ground, in an open area, since it must have a clear view between it and the gunship.

b. It is O.K. to build a sandbag revetment around the beacon, but don't cover up the top of the beacon. Do not damage the white knobs (antennas) on top of the beacon.

c. Keep the beacon at least 10 meters away from large metal objects, such as corrugated steel and artillery pieces.

2. When the ALO relays the message to you to turn to the beacon, move the "operate" - "off" - "charge" switch at the side of the beacon to "operate". No further action is required. If no word is heard from the ALO, turn the beacon to "operate" when the Stinger aircraft requests it.

3. When in radio contact with Stinger, ask the aircraft whether it can "see" the beacon on his radar. If it can, call out targets in relation to the position of the beacon, not to your position.

* Pass the following information for point targets.

- a. Type of Target.
- b. Magnetic bearing to Target from beacon.
- c. Range to Target from beacon up to 1,000 meters.
- d. Elevation of Target.
- e. Location of nearest friendlies.

* Pass the following information for area targets.

- a. Type of Target.
- b. Magnetic bearing of Target Boundaries, from the beacon. I.E., "from 200 degrees to 240 degrees".
- c. Ranges of Target Boundaries, from the beacon, I.E. "from 400 meters to 700 meters".
- d. Elevation of Target.
- e. Location of nearest friendlies.

* Do not hold a magnetic compass close to the beacon. There is a strong magnet inside.

* Use standard techniques to adjust the Gunship firing, if you can see where his rounds are hitting.

4. The computer in the Gunship cannot accept targets over 1,000 meters from the TAFSEA beacon for offset firing of the guns.

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[illegible][illegible]

5. The gunship cannot fire closer than 200 meters from friendly troops, unless it can "see" the target with its other sensors. Then it can fire within 100 meters of friendlies. If the Ground Commander declares a Combat Emergency the gunship will fire closer than 100 meters to friendlies.

610

6. After the Gunship has left the area, turn the TAFSEA beacon switch to "off".

And if

CHRG

7. After the beacon has operated for 16 hours actively, it will need to have its batteries recharged. Return it to DASC for recharging.

EA

8. Report mission results of the Gunship firing by use of the TAFSEA beacon. Use the nickname, COMBAT RENDEZVOUS. Pass BDA through to the DASC. Report any difficulties in use or operation of the beacon. Report the weather conditions during the firing period.

FIGURE 22A

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FOOTNOTES

1. (S) Msg (S) 090412Z Aug 69, PACAF to TAC, Subject: Offset Firing with AC-130; and, Memo (S) 7/13AF DO to 7/13AF CD, 14 Apr 71, Subj: Pave Mace/Combat Rendezvous.
2. (S) Ltr (C) USAF/AFXOWQ to Director of Doctrine and Systems, ACS/ Force Development, USA, 4 June 70, Subj: Gunship Close Air Support for US Army; and Memo (S) 7/13AF DO to 7/13AF CS, 14 Apr 71.
3. (S) Interview, topic: Pave Mace/Combat Rendezvous with Lt Col Negus, 7AF DOX, by Capt Adolf Zabka, at Tan Son Nhut AB, RVN, 21 Feb 72.
4. (S) Information for this section is taken from the following sources: Gunship Offset Firing Capability, (FOUO), undated; 16 SOS Tactics Manual Classified Supplement (S) 1 Oct 71, chpt 11; 7AF talking paper, Use of Ground Radar Beacons, (C) 9 Oct 70; Memo, (S) 7/13ADO to 7/13 CD, 14 April 71; Msg (S) 052227Z April 71, ASD to 7/13AF, Subj: Pave Mace/Combat Rendezvous; Msg (S) 140310Z April 71, PACAF to 7AF, Subj: Pave Mace/Combat Rendezvous; Msg (S) 142041Z April 71, ASD to 7/13AF Subj: Pave Mace/Combat Rendezvous; Msg (S) 221730Z April 71, ASD to PACAF, Subj: Pave Mace; Msg (S) 310045Z Dec 71, 7/13AF to 7AF, Subj: Evaluation and Recommendations of USAF Ground Strike Beacons; Msg (S) 241200Z Jan 72, RADC to 7AF, Subj: AN/PPN-17 Beacon Msg (S) 251222Z Jan 72, MACV to XXIV Corps, Subj: Transponders; Msg (S) 072030Z Feb 72, RADC to ASD, Subj: AN/PPN-17 Beacon; 16 SOS History, July-Sept 71, pp 30-32; Interview (S) topic: Combat Rendezvous, with Lt Col Melvin McGuire Commander Det 1, 18 SOS by Col Thomas Wade at Da Nang AB, RVN 27-28 March 72; Msg (C) 280800Z Jan 72, 8TFW to 7AF, Subj: Test of AN/PPN-17 Transponder; and Msg (C) 290550Z Jan 72, ASD/OL to RADC, Subj: AN/PPN-17 Beacons; and Msg (C) 121933Z May 72, ASD to CSAF, Subj: Gunship Sensors. In some instances these sources give conflicting information. Where these conflicts could not be resolved, the author has used what he considers to be the most reliable information.
5. (S) Information for this section is taken from the following sources: 16 SOS Tactics Manual, Classified Supplement, (S) 1 Oct 71, Chpt 11; Ltr (S) undated, 16 SOS to Pave Mace Aircrews, Subj: Pave Mace Procedures; Pave Mace Operations Plan (S) undated; Msg (C) 201943Z Oct 71, ASD to ASD/OL., Subj: TEMIG/Pave Mace Beacons; and Ltr (S), 5 Dec 72, Hq PACAF (DOOF) to Hq PACAF (DOAD), Subj: Pave Mace/Combat Rendezvous.

6. (S) Information for this section is drawn from the following sources: 16 SOS Tactic Manual, (U) 1 Oct 71, Chpt 10; 16 SOS Tactical Manual Classified Supplement (S) 1 Oct 71 Chpt 11; Ltr, (S) 16 SOS to Pave Aircrews, undated, Subj: Pave Mace Procedures; Pave Mace Operations Plan, (S) undated; Operation of TAFSEA Beacon with Stinger AC-119K Gunship (C) undated; AC-130 "Pave Mace" Gunship Operations Plan, 11 May 71; 7AF Oplan 796, (S) Combat Rendezvous Operations Plan 11 June 71; 7AF Oplan 797, (S) Pave Mace Operations Plan; Msg (S) 221117Z Jan 72, 8TFW to 7/13AF, Subj: Pave Mace Report; and Instructions for X-band or TEMIG Beacon Operations. (S) undated. Tactics and procedures have changed over the years and continued to change even as this report was being prepared. Therefore, the information is valid only for the time it was written and is included only to provide the reader with a general idea of the tactics and procedures involved.
7. (S) Ltr, 7AF DO to COMUSMACV/J3, 17 Feb 70, Subject: AC-119K Gunship Close Air Support tactics and techniques.
8. (C) Ltr, 4 June 70.
9. (S) Ltr, 17 Feb 70.
10. Ibid.
11. (C) Ltr, 4 June 70.
12. Ibid.
13. (S) Ltr, 17 Feb 70.
14. (S) Ibid., and Ltr (S) AFXOWO to TAC, 16 Aug 68, subject: Gunship Demonstration for the Army.
15. (S) Minutes of Combat Rendezvous Conference, 11 Sep 1968.
16. (S) Msg 252325Z Nov 68, USAFSOF to TACDOSO. Subject: Phase I Combat Rendezvous Final Report.
17. Ibid.
18. Ibid.
19. Ibid.
20. (C) Ltr, 4 June 1970.
21. (S) Msg (S) 090412Z Aug 69, and Memo (S) 7/13AF DO to 7/13AF CS, 14 Apr 71.

22. (S) Msg (S) 280523Z Aug 69, PACAF to CSAF, subject: Offset Firing with AC-119/130, and Ltr, 4 June 70.
23. (C) Ltr (C) 7AF DPL to MACV, 12 Apr 70, Subject: AC-119K Gunship Close Air Support Tactics and Techniques states that the tests were conducted in Dec 69; AFSC ASD/ASJT-2 Final Test Report, Project 4366, 1 June 70 states that the tests were held in Dec 69 and Jan 70; while Ltr, 4 June 70 gives 27 Jan - 4 Feb as the dates; and Msg (C) 122040Z Feb 70, CSAF to CINCPACAF, subject: Combat Rendezvous says that the tests were concluded on 3 Feb 70.
24. (C) Msg, 122040Z Feb 70.
25. (S) Msg (S), 011927Z May 60, CSAF to PACAF, Subject: Combat Rendezvous Phase II.
26. (S) Msg 270321Z April 71, PACAF to ASD, Subject: Pave Mace/Combat Rendezvous.
27. (S) Msg 270321Z Apr 71 and Project 4366 Final Report.
28. (S) Ltr 17 Feb 70.
29. (C) Msg 122040Z Feb 70.
30. (S) Draft MACV Joint Test Order, Combat Rendezvous, February 1970, and Msg 270321Z Apr 71.
31. (S) MACV JTO, Feb 70.
32. Ibid.
33. Ibid.
34. (C) Ltr MACV/J3 to 7AF, 17 Mar 70, Subject: AC-119K Gunship Close Support Tactics and Techniques.
35. (C) Ltr, 7AF/DPL to MACV, 12 Apr 70, Subject: AC-119K Gunship Close Air Support Tactics and Techniques.
36. Ibid.
37. (S) Msg 280403Z Apr 70, CSAF to PACAF, Subject: Combat Rendezvous Phase II.
38. (S) Msg 011927Z May 70, CSAF to PACAF, Subject: Combat Rendezvous Phase II.
39. (S) Msg 182220Z May 70, CSAF to PACAF, Subject: Combat Rendezvous Phase II.

40. (S) Msg 220545Z Feb 70, 7AF to 8TFW, Subject: Out-country Troops-in-Contact Support.
41. (S) Msg 041015Z Apr 70, 7AF to 14SOW, Subject: AC-119K Offset Firing Mode.
42. (S) Msg, (C) 210922Z Apr 70, 14SOW to 7AF, Subject: Mini Combat Rendezvous, and 18 SOS paper (S) APQ-133 Beacon Tracking Radar, 27 Mar 72.
43. Ibid.
44. (S) Msg 020201Z May 70, 14 SOW to ASD, Subject: Offset Firing with AC-119.
45. (S) Msg (C) 170732Z May 70, ALO/IFFV to 7AF, Subject: Stinger Demonstration, and 18 SOS paper, 27 Mar 72.
46. (S) Msg (C) 240425Z May 70, 14 SOW to 7AF, Subject: Combat Rendezvous Phase II; Msg (C) 240426Z May 70, 14 SOW to 7AF, Subject: Combat Rendezvous Phase II, and 18 SOS paper, 27 Mar 72.
47. (C) Msg 240425Z May 70
48. (C) Msg 240426Z May 70
49. Ibid.
50. (C) Msg 270225Z May 70, CG IFFV to 7AF, Subject: Stinger/Radar Transponders.
51. (C) Ltr 7AF to PACAF, 21 June 1970, subject: Combat Rendezvous.
52. (S) 18 SOS paper, 27 Mar 71
53. (S) Msg (S) 051435Z July 70, 14 SOW to 7AF, subject: Combat Rendezvous Phase II, and Msg (S) 060920Z Aug 70, 14 SOW to 7AF, subject: Combat Rendezvous Phase II.
54. (S) Ltr 7AF to PACAF 21 June 70; Msg 051435Z July 70; and Ltr (C) 7AF to 8TFW, 9 July 70, subject: Combat Rendezvous Phase II.
55. (C) Msg 010940Z Jul 70, 14SOW to 7AF, subject: Combat Rendezvous Phase II.
56. (C) Ltr 7AF to 8TFW, 9 Jul 70, subject: Combat Rendezvous Phase II.
57. (S) Gunship Offset Firing Conference, Hq PACAF, 20-22 July 1971, pp. 3-4.

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58. (S) Msg 270845Z Oct 70, 14SOW to 7AF, subject: Removal of APQ-133 Beacon Tracking Radar Class A Components.
 59. (C) 7AF position on Gunship Offset Firing Capability July 1971.
 60. Ibid.
 61. Ibid.
 62. (S) Ibid., and Msg 160034Z Mar 71, CINCPACAF to 7AF, subject: Combat Rendezvous.
 63. (C) Ltr, 4 June 1970.
 64. (C) Msg 091646Z Mar 71, CSAF to PACAF, subject: Combat Rendezvous.
 65. (S) Msg (C) 160034Z Mar 71, PACAF to 7AF, subject: Combat Rendezvous
Msg (S) 210701Z Mar 71, 7AF to CSAF, subject: Combat Rendezvous;
and 18 SOS paper, 27 Mar 72.
 66. (S) 18 SOS paper, 27 Mar 72.
 67. (C) Msg 091646Z Mar 71.
 68. (S) Msg 160034Z Mar 71.
(S) Ltr, Hq PACAF (DOQ) to Hq PACAF (DOA), 11 Dec 1971, subj: CHECO
Report: Pave Mace/Combat Rendezvous.
 69. Ibid.
 70. (C) Msg 091646Z Mar 71.
 71. (S) Msg (S) 140310Z Apr 71, PACAF to 7AF, subj: Pave Mace/Combat
Rendezvous.
 72. (S) Msg (S) 081927Z June 71, SAD to 7AF, subj: Gunship Beacon Off-
set Conference; and Msg (U) 052230Z Nov 71, ASD to PACAF, subj:
Pave Mace Engineering Change and Training to Incorporate Decoder
into the AN/ASD-5 Direction Finder Set.
 73. (S) Seventh Air Force Conference on Gunship Beacon Offset Firing
Capability, 27 May 71, p. 8.
 74. (S) Msg 081927Z June 71, ASD to 7AF, subject: Gunship Beacon Offset
Conference.
 75. (S) 7AF Conference, 27 May 1971, pp. 6-7.
 76. (S) Ibid., and 7AF position on Gunship Beacon Offset Firing Capability,
15 June 1971, p. 2.

- [REDACTED]
77. (S) Msg 141200Z April 1971, 7/13AF to USAIRA, Vientiane, subject: Pave Mace/Combat Rendezvous; Memo 7/13AF DO to 7/13AF CD, 14 April 1971, subject: Pave Mace/Combat Rendezvous; Msg 240300Z April 71, 7/13AF to 7AF, subject: Pave Mace; and Msg (S) 050520Z April 71, AFSSO Udorn to AFSSO TSN, subject: Gunship Support in BR.
 78. (S) Msg 141200Z April 71
 79. (S) Msg 050520Z April 71
 80. (S) Ibid.
 81. (S) Ibid; and Msg 221055Z April 1971, 8 TFW to 7/13AF, subject: Pave Mace Mission.
 82. (S) Msg 221055Z April 1971
 83. (S) No DTG, addressee or subject, but marginally noted as 15 April 1971 in 7/13AF File Ops 9-6, 1971 Pave Mace contains the Ops Plan for this mission. Msg 030710Z May 71, 7/13AF to 7AF, subject: Pave Mace, contains mission report.
 84. (S) Memo 7/13AF/DO to CD, 14 April 1971
 85. (S) 7AF position, 15 June 1971, attachment 5.
 86. (S) Ibid, p. 2.
 87. (S) Msg 081927Z June 1971, ASD to 7AF, subject: Gunship Beacon Offset Conference.
 88. (S) Msg 171150Z April 1971, 7/13AF to 7AF, subject: Pave Mace/Combat Rendezvous.
 89. (C) Ltr, 7AF/DAFSC to 7AF/DOP, 17 April 1971, subject: Pave Mace.
 90. (S) Msg, 240300Z April 1971, 7/13AF to 7AF, subject: Pave Mace.
 91. (S) Msg, 280301Z April 1971, 7AF to 7/13AF, subject: Pave Mace.
 92. Ibid.
 93. (S) Msg 030710Z May 1971, 7/13AF to 7AF, subject: Pave Mace.
 94. (S) Msg 060750Z May 1971, 7AF to 7/13AF, subject: Pave Mace.
 95. (S) Msg 171150Z April 1971.
 96. (S) Memo, 7/13AF/DO to 7/13AF/CD, 14 May 1971.

- [REDACTED]
- 97. (S) Msg 190930Z May 1971, 7AF to AFSC, subject: SAR Application of Pave Mace Beacon.
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GLOSSARY

AAA	Anti-Aircraft Artillery
AAFSS	Advanced Aerial Fire Support System
ABCCC	Airborne Battlefield Command and Control Center
AFSC	Air Force Systems Command
AGL	Altitude from Ground Level Above Ground Level
ALO	Air Liaison Officer
ASD	Aeronautical Systems Division
BC	Black Crow
BDA	Bomb Damage Assessment Battle Damage Assessment
BLUE CHIP	7AF Command and Control Center (7AFCCC)
BTR	Beacon Tracking Radar
CAS	Controlled American Source
CDC	Combat Development Command
CEA	Circular Error Average
CEP	Circular Error Probable
CIU	Control Indicator Unit
CONUS	Continental U.S.
CROC	Combat Required Operational Capability
CSS	Combat Sky Spot
DASC	Direct Air Support Center
DM	Director of Materiel
DMZ	Demilitarized Zone
FAC	Forward Air Controller
FAG	Forward Air Guide
FCC	Fire Control Computer
FCO	Fire Control Officer
FCS	Fire Control System
FVV	Field Forces, Vietnam (I FVV - First Field Forces Vietnam)
FLIR	Forward Looking Infrared
FOL	Forward Operating Location
GDA	Gun Depression Angle
IFF	Identification, Friend or Foe
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
JTO	Joint Test Order
KBA	Killed by Air

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LMSC	Lockheed Missile and Space Company	roup
LOC	Line of Communication	roup
LWL	Limited Warfare Laboratory	
MAC	Military Airlift Command	
MACSOG	Military Assistance Command, Studies and Observation Group	
MAP	Military Assistance Program	
MR	Military Region	
NKP	Nakhon Phanom, A Royal Thai Air Force Base	roup
NM	Nautical Mile	
NOS	Night Observation Sight	
NVA	North Vietnamese Army	
NWL	Naval Weapons Laboratory	
OPLAN	Operations Plan	
OT & E	Operational Testing and Evaluation	
PDJ	Plaines des Jarres	
PSP	Pierced Steel Planking	
RNO	Results not Observed	
ROE	Rules of Engagement	
RTAFB	Royal Thai Air Force Base	
RTB	Return to Base	
RTU	Receiver Transmitter Unit	
RVN	Republic of Vietnam	
SAM	Surface to Air Missile	
SAR	Search and Rescue	
SHORT ROUND	Round of ammunition or bombs which fell short of the target. Usually used in conjunction with casualty to friendly forces or non-combatants	
SLA	Sight Line Angle	
SOF	Special Operations Force	
SOS	Special Operations Squadron	
SOW	Special Operations Wing	
SPO	Systems Project Officer	
TACAIR	Tactical Air (Support)	
TACM	Tactical Air Command Manual	
TAS	True Airspeed	
TEMIG	Tactical Electro-Magnetic Ignition Generator	
TFW	Tactical Fighter Wing	
TIC	Troops in Contact	
TOT	Time on Target	
TRAC	Third Regional Assistance Command (Army)	
TSN	Tan Son Nhut Air Base, Vietnam	

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UHF
USARV

Ultra High Frequency
U.S. Army, Vietnam

VFR
VMC
VNAF

Visual Flight Rules
Visual Meteorological
Vietnamese Air Force

UNCLASSIFIED

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